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THE DIAGNOSIS OF TRAUMATIC MAIN-VESSEL THROMBOSIS

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OCCLUSION of the main vessel of the lower limb is commonly segmental (Leriche, Fontaine, and Dupertius, 1937), the femoral artery in Hunter's canal being the usual site of the thrombosis (Lindbom, 1950; Krahl, Pratt, Rousselot, and Ruzicka, 1954; Lowenberg, 1954; Mavor, 1956). The popliteal artery is also affected though much less frequently (Lindbom, 1950; Mavor, 1956). The underlying pathology in the great majority of cases is atheroma, but there remain instances where the thrombosis cannot be explained on this basis. In these the diagnosis of thrombo-angiitis obliterans is likely to prove more speculative than accurate (Boyd, Ratcliffe, Jepson, and James, 1949; Mavor, 1955), and should not be made just because the patient is younger than an 'arteriosclerotic' should be. There always exists the possibility of a traumatic aetiology, which should be considered in spite of the absence of a definite history of injury. Although it is recognized that short of histological examination of the resected arterial segment, there are difficulties in making such a diagnosis, it is felt that with a knowledge of the usual site of onset and extent of thrombosis, these will be largely resolved. It is important to make an accurate diagnosis wherever possible, not only to establish the prognosis, which obviously is much more favourable in cases where trauma is a possibility than in those where the artery is diseased or degenerating (Mavor, 1953), but also as a guide to treatment, which with the recent advent of surgery for the occluded artery (Hufnagel and Eastcott, 1950, 1951, 1952; Fontaine and Hubinot, 1950; Julian, Dye, Olwin, and Jordon, 1952; Rob and Eastcott, 1953) is more likely to be direct than indirect.

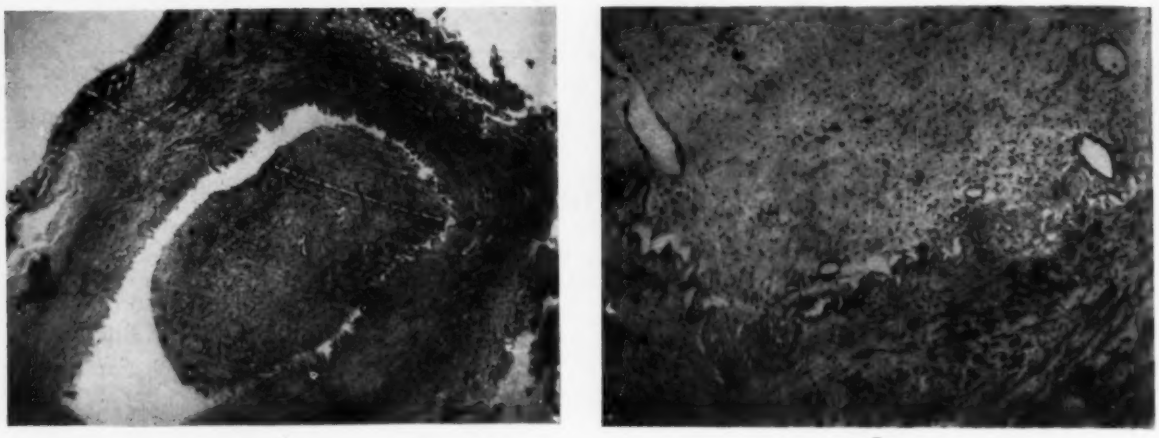
Clinical Material.—In a recent investigation (Mavor, 1953) of 164 consecutive cases of peripheral arterial insufficiency in the lower leg, 5 cases (*Table I*) were encountered where the diagnosis of traumatic thrombosis was made. In 3 of these cases confirmation was obtained by resection and histological examination of the thrombosed arterial segment (*Case* 2, *Fig.* 402). In the other 2 cases, however, the diagnosis was not conclusive, being suggested by the site of the thrombosis and the arteriographic picture. Apart from full clinical examination and arteriography, urinalysis, X-ray examination of chest and legs, blood-Wassermann and Kahn tests, blood-urea and cholesterol estimations, full blood-counts and electrocardiography were carried out in these cases. No abnormalities in these investigations were noted.

Table I.—CASES OF TRAUMATIC THROMBOSIS

CASE NO.	SEX	AGE	HISTORY OF TRAUMA	SITE OF THROMBOSIS	BASIS FOR DIAGNOSIS
1	M.	33 yr.	—	Superficial femoral artery in entire extent	1. Arteriography 2. Histological examination
2 (*Figs.* 402, 403)	M.	32 yr.	—	Distal popliteal artery	1. Arteriography 2. Histological examination
3 (*Fig.* 404)	M.	37 yr.	Hyperextension of knee-joint	Popliteal artery in entire extent	1. History 2. Arteriography (No histological examination)
4 (*Fig.* 405)	M.	40 yr.	Hyperextension of knee-joint	Popliteal artery in entire extent	1. History 2. Arteriography 3. Histological examination
5 (*Fig.* 406)	M.	45 yr.	—	Popliteal artery in entire extent	1. Arteriography (No histological examination)

Arteriographic Findings.—The arteriographic picture in the case of femoral artery thrombosis shows occlusion of the vessel from the origin of profunda femoris to the adductor magnus opening area (Mavor, 1952). Of the 4 cases of popliteal thrombosis, 1 shows distal occlusion of the popliteal

artery (*Fig.* 403), while the others demonstrate blockage of the vessel in its entire length (*Fig.* 404). The latter is regarded as a late picture, as the arteriographic evidence suggests that occlusion begins in the distal popliteal (Griffiths, 1948; Boyd,



A B

FIG. 402.—A, Section through the proximal popliteal artery showing the area of the propagated thrombus. The artery is healthy. B, Section through the popliteal artery showing the probable site of formation of the original thrombus. Organization has bridged the gap between thrombus and intima. This section was taken from the area indicated by the arrow in *Fig.* 403 B, about midway between joint-line level and the bifurcation of the vessel.

A B

FIG. 403.—A, B, Traumatic popliteal artery thrombosis. The thrombosis affects the popliteal artery in its distal two-thirds.

Ratcliffe, Jepson, and James, 1949). From there thrombosis will propagate quickly in both directions, but mainly proximally, until the popliteal is occluded in its whole length, so that this is the usual arteriographic finding. The main vessel is healthy, as are the collateral channels and the lower leg vessels (*Figs.* 403 B, 404 D).

FACTORS IN AETIOLOGY

In some cases the trauma is undoubted, there being direct damage to the artery, if not in continuity, certainly severe enough to initiate thrombosis. Dislocations, simple fractures, penetrating wounds with or without fractures may be so complicated, a posterior dislocation of the knee-joint being probably the most common example of this peculiar type of injury (Mavor, 1952). In the latter it should be noted that the site of thrombosis is above joint-line level opposite the femoral condyles (Boyd and others, 1949), which is where greatest displacement of the artery occurs.

Where there is no history of trauma, the patient's habits and occupation should be inquired into, as it is possible that minor strains or habitual movements may play a role in aetiology (Learmonth, Blackwood, and Richards, 1944). The likelihood of this is never very convincing, and in such cases an explanation of the thrombosis may be found in the particular susceptibility of a portion of the main-stem artery in relation to its anatomy. There are at least two sites where it is recognized that the main artery of the lower limb is subjected to unusual stresses, at the adductor magnus opening area and in the popliteal fossa.

At the adductor magnus opening there is a canal bounded by the adductor and hamstring portions of the adductor magnus muscle, where there is direct continuity of the general fascia of the muscles with the adventitia of the artery (Mavor, 1952). Here muscle pull and compression may cause angulation of the vessel, and this displacement has been demonstrated radiologically by Lindbom (1950). As a result subintimal hæmorrhage may occur and initiate thrombosis, which in time may propagate proximally to the origin of the profunda femoris, being limited in its distal extension by the constant muscle branch to vastus medialis and the descending genicular artery, both of which arise just before the artery leaves the femoral canal (Mavor, 1956). Further corroboration that the femoral artery is subjected to unusual stresses at this point comes from the fact that in atheroma secondary thrombosis commences here in 85 per cent of all cases (Lindbom, 1950; Mavor, 1956). However, there is no doubt that traumatic femoral artery thrombosis without antecedent injury is very rare. Learmonth,

Blackwood, and Richards (1944) reported 1 case where the diagnosis was confirmed histologically, and there is only 1 case in the present study. It has been previously reported (Mavor, 1952).

The susceptibility of the popliteal artery to thrombosis is well known. In an endeavour to explain this, various anatomical factors which may play a role have been described. It is obvious that any artery crossing a major flexion crease is subjected to an unusual amount of movement, but it is equally obvious that this cannot be cited as an aetiological factor here in the absence of the localization of thrombosis at other flexion creases. Boyd and others (1949) believe that the fascial covering which the artery receives from the gastrocnemii may form a constricting band, and further that abnormal fixation of the artery may occur from inflammatory changes in the popliteal fossa resulting from minor infection of the toes or interdigital folds. They state that traumatic popliteal thrombosis commences at joint-line level, presumably the level of the constriction or abnormal fixation.

On radiological examination of the popliteal artery in the fœtus, it can be readily demonstrated that with extension of the knee-joint the vessel is stretched and narrowed (*Fig.* 405), changes which become even more pronounced with hyper-extension. These changes are usually most marked in the distal half of the artery below joint-line level. It is of significance that this portion of the artery (*Fig.* 405) often is devoid of branches (Lindbom, 1950), possibly because of its close capsular relationship. Without the anchoring function which branches normally perform, it is thus susceptible to longitudinal stretching on hyperextension. This has been recognized for some time and was recently re-emphasized by Nicholson, Foster, and Heath (1955), who investigated the influence of hyperextension of the knee on circulation in the lower leg, finding that it was the significant factor in causing vascular complications in cases subjected to Bryant's traction with or without elevation of the leg. The clinical evidence available also suggests that hyperextension may be an aetiological factor in producing acute damage to the artery with resultant thrombosis, as of the 4 cases of popliteal thrombosis reported here, 2 had hyperextension injuries antedating the onset of their peripheral ischæmia. Furthermore, arteriographic findings indicate that the usual site of early occlusion in cases of traumatic popliteal thrombosis is in the distal branch-free portion of the vessel

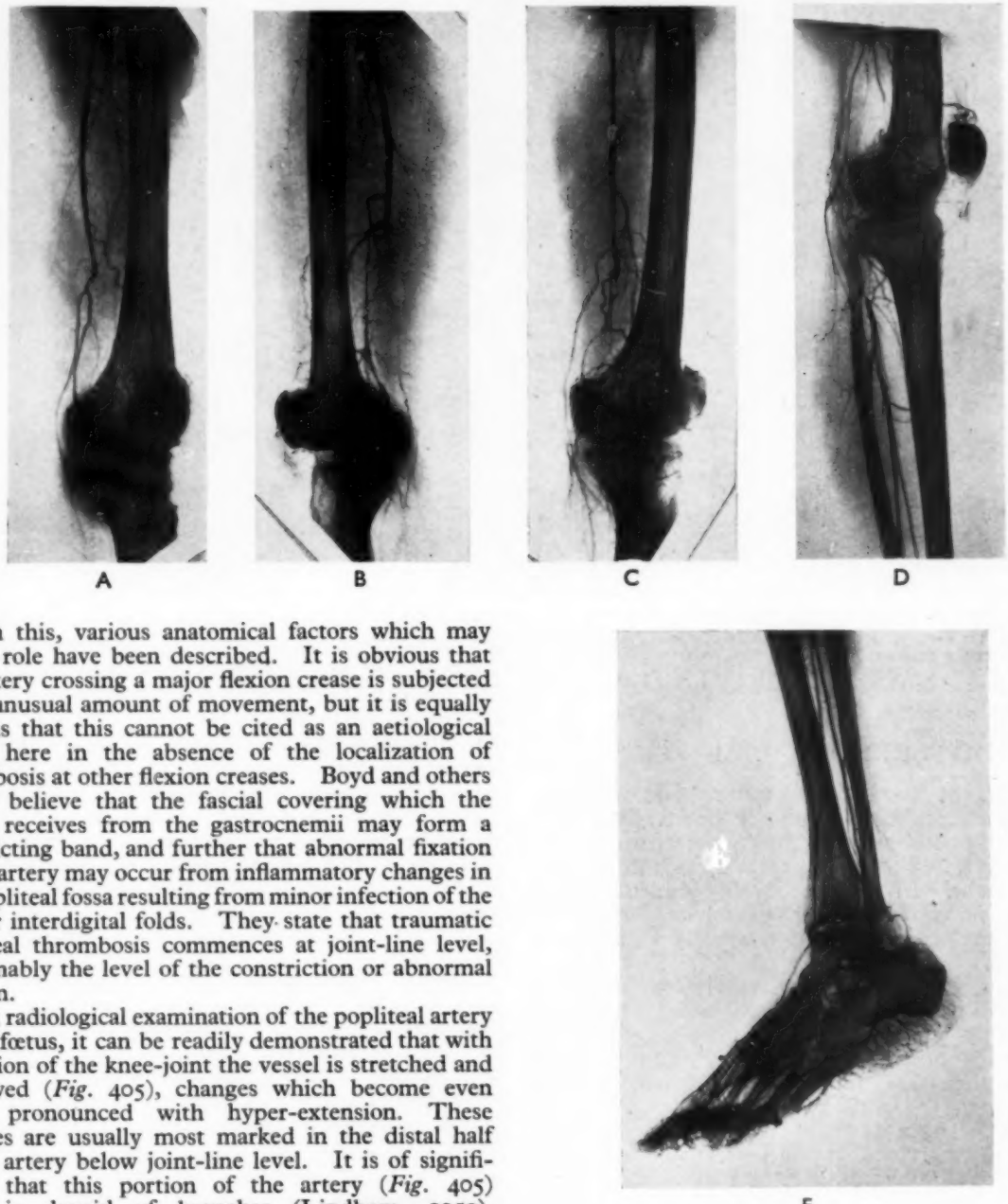
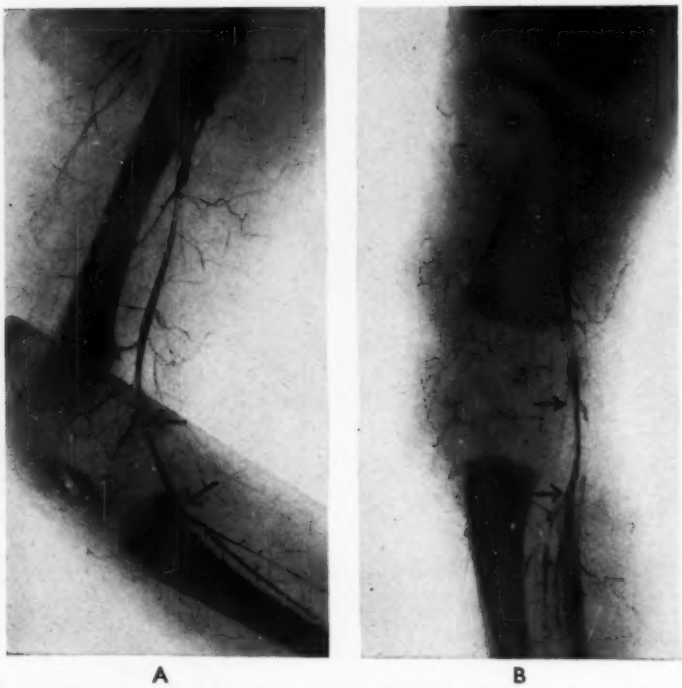


FIG. 404.—A–C, The arteriograms show occlusion of the whole length of the popliteal artery. D, E, The collateral and lower leg vessels show no evidence of disease.

(*Fig.* 404 A). There is only one such early arteriogram in this study, but arteriograms published by Griffiths (1948) and by Boyd and others (1949) also illustrate this point. It is worth noting that Griffiths's patient received a hyperextension injury of the knee-joint.

Most cases of main-vessel thrombosis are secondary to atheroma. When the popliteal artery is the site of secondary thrombosis, the occlusion arises usually in the proximal part of the vessel at the site of origin of the large sural branch (*Fig.* 406).



A B

FIG. 405.—A, B, Arteriogram studies in the dead fœtus. The distal portion of the popliteal artery, indicated by arrows, is free of branches, and is notably narrowed by extension. (*By courtesy of Dr. Floyd Bliven, Department of Orthopædics, University of Rochester Medical School.*)

FIG. 406.—Thrombosis of the popliteal artery secondary to atheroma. The thrombus has propagated both proximally and distally from the origin of the sural branch, where atheroma is often most marked.

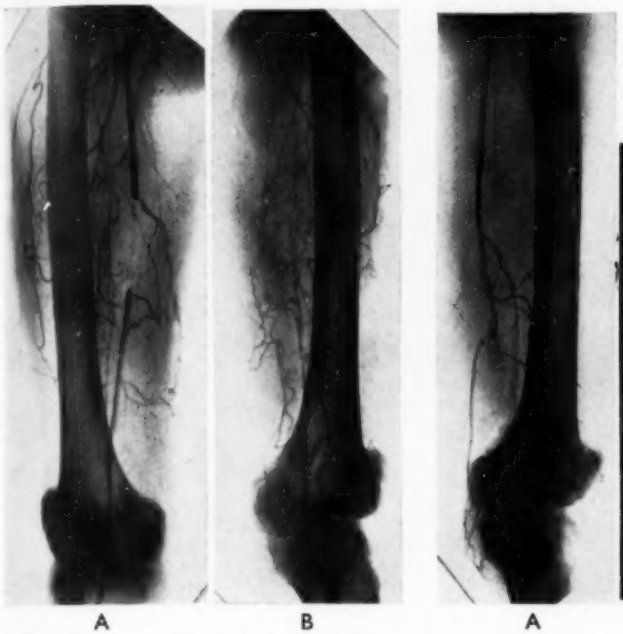
DIFFERENTIAL DIAGNOSIS

Where the thrombosis is traumatic in origin, the popliteal is much more commonly the site of occlusion than the femoral artery. Furthermore, in the case of the latter, a history of direct trauma is more likely to be present. In the absence of a traumatic history, the problem of diagnosis may resolve itself into the task of excluding either inflammatory disease or atheroma.

Age in itself is no safe criterion of diagnosis. Youth does not preclude atheroma, and it is becoming increasingly apparent that this disease may affect the arteries of the extremities of much younger patients than has hitherto been thought likely (Mavor, 1955). Although usually regarded as affecting younger patients, there is no particular reason why traumatic thrombosis should not occur in older age groups, and in fact in this study the 4 cases of popliteal thrombosis have ages of 32, 37, 42, and 45 years respectively. However, it is probable that the clinical diagnosis of traumatic thrombosis should be restricted to patients under 40 years of age, as it is only under such an age that the likelihood of a healthy vessel exists. In older age groups trauma of similar or even less degree may produce thrombosis, as the artery may already be atheromatous and thus more susceptible to damage.

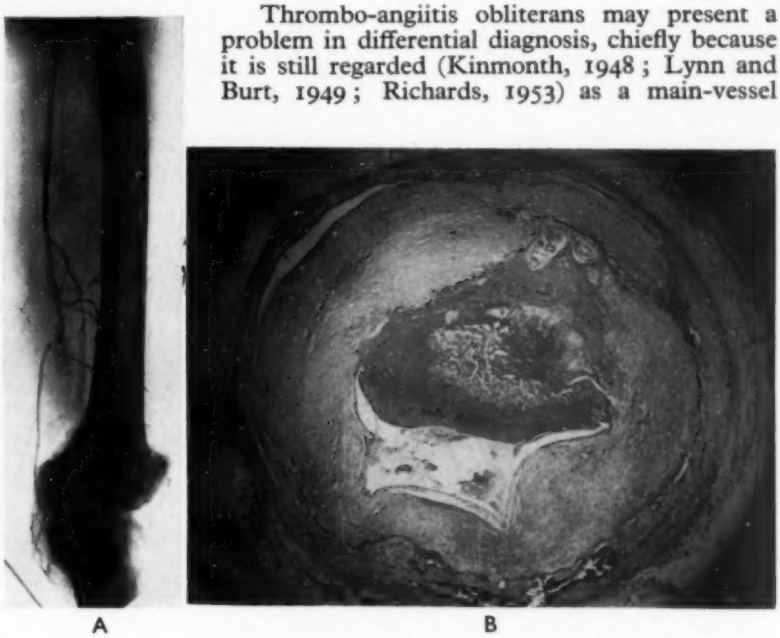
By dissection studies and arteriography, Lindbom (1950) has shown that this is the site where atheromatous changes are most marked in the popliteal artery, and in a recent study of the pattern of occlusion in atheroma of the lower-limb arteries, it was noted to be the site of thrombus origin in 15 out of 16 cases of popliteal occlusion (Mavor, 1956). However, from that area thrombosis may extend to involve the whole popliteal, so that when seen late, as in 3 of the cases reported here, this important differential point cannot be used in diagnosis. Boyd and others (1949) state that the arteriographic picture in secondary popliteal thrombosis resembles that of traumatic or primary popliteal thrombosis. This, however, is not the case, as is borne out by their arteriogram illustrating secondary popliteal thrombosis. It shows proximal popliteal thrombosis, a patent distal vessel, and distinctive signs of atheroma. These radiographic signs of atheroma have been fully described by Lindbom (1950), the most significant findings being irregularity of the intima, 'pinching' of the origins of branches as they arise from the main vessel, and the presence of intimal calcification which is not in plaques. The latter represents old intimal hæmorrhages and requires careful technique. Nevertheless, despite the radiographic appearances mentioned, it is possible for atheroma to be so localized in the main vessel that except for occlusion no abnormality exists in the arteriogram (*Figs.*

407 A, 408 A). Experience suggests that where such occlusion is not at a site usual for traumatic thrombosis, the diagnosis, despite the arteriographic appearances, is most likely to be atheroma with secondary thrombosis. This can be confirmed often by investigation of the opposite side, which may or may not be the site of symptoms (*Fig.* 407 B), or in the last resort by histological examination of the resected arterial segment (*Fig.* 408 B), as in the following illustrative case:



A B

FIG. 407.—A, Occlusion of the right femoral artery in its lower part secondary to atheroma. The radiological signs of atheroma are minimal. B, Left femoral arteriogram in the same patient. The proximal artery is obviously diseased.



A B

FIG. 408.—A, Thrombosis of the popliteal artery in its entire length. There is no radiological evidence of atheroma. B, Section through the thrombosed popliteal artery above joint-line level, showing medial sclerosis and calcification and subintimal hæmorrhage into an atheromatous area of the intima.

J. S., aged 48 years, was admitted to Aberdeen Royal Infirmary on March 18, 1952, with the main complaint of intermittent claudication affecting the left calf. Two months previously, while helping to lift some heavy furniture, he suffered pain behind the left knee-joint, and later noted numbness and coldness of the left foot. The next day intermittent claudication was definite. His exercise tolerance had remained approximately 150 paces. He also complained of coldness and pallor of the left foot, markedly aggravated by exercise. There was no rest pain. Examination—significant changes were found in the left leg and foot. There was no abnormality of the skin at rest, but on exercise a generalized pallor of the left foot appeared, associated with coldness. The only pulse palpable on the left side was the femoral, in contrast to the right side where all the peripheral pulses were present. The blood-pressure was normal, the electrocardiogram negative, and there was no radiological evidence of vascular calcification in the lower limbs. Femoral arteriography demonstrated a popliteal thrombosis, extending to the bifurcation of the artery (*Fig.* 408 A). The collateral circulation was good, and there was a notable absence of evidence of disease either in the femoral or lower leg arteries. Arteriectomy was undertaken, and histological examination revealed an atherosclerotic vessel (*Fig.* 408 B).

Comment.—The histological picture in this case demonstrates intimal hæmorrhage and thrombosis, a state of affairs which is of common occurrence in atherosclerotic vessels (Lindbom, 1950). Clinically, the diagnosis of traumatic thrombosis seemed certain on the basis of the history of injury, which was of a hyperextension type, and the absence of evidence of atherosclerosis either clinically or arteriographically. This case underlines the inherent difficulties of diagnosis in some cases without resection of the thrombosed arterial segment, and into this category of doubtful diagnosis must be placed *Case* 5 in this series.

Thrombo-angiitis obliterans may present a problem in differential diagnosis, chiefly because it is still regarded (Kinmonth, 1948; Lynn and Burt, 1949; Richards, 1953) as a main-vessel occlusive disease. It is becoming increasingly apparent that this may be an inaccurate appreciation of the disease (Mavor, 1955), likely to lead to an erroneous diagnosis, particularly in the younger patient with intermittent claudication. Boyd (1938), who reported several cases of main-vessel thrombo-angiitis obliterans, has since retracted his opinion, believing now (Boyd and others, 1949) that several were cases of atheroma with secondary thrombosis, while the majority were cases of occlusion secondary to trauma. The present position seems to be that main-vessel thrombo-angiitis obliterans is an uncommon type of the disease, if it exists at all, and that in patients under the age of 30–35 years, the cause of exercise calf pain is likely to be traumatic thrombosis and not inflammatory arterial disease.

There remain instances, however, where the diagnosis cannot be made on a clinical basis. Some of these cases may be odd examples of local arteritis with occlusion, which proves to be localized or locally advanced cases of periarteritis nodosa (Mavor, 1955). Others may have no indication of inflammatory reaction in the vessel wall, and remain unexplained. That such cases exist was first recognized by Leriche and Stricker (1933), who named them "spontaneous localized monarteritis of indeterminate origin".

With these considerations in mind, it seems clear that the diagnosis of traumatic main-vessel thrombosis requires final confirmation from histological

examination. It is doubtful whether biopsy in itself is justifiable, as collateral vessels may be destroyed. Reconstitution of the occluded artery by direct surgery in the nature of either a direct end-to-end or shunt arterial homograft is indicated in these cases, and resection of the thrombosed arterial segment in whole or in part should await its execution.

SUMMARY

1. The aetiological factors in main-vessel thrombosis secondary to trauma are considered. In popliteal artery occlusion hyperextension of the knee-joint is an important type of injury, and is responsible for the higher incidence of popliteal occlusion as compared to femoral.

2. The arteriographic picture in 5 cases is presented. When first seen, thrombosis of the whole length of the popliteal artery is usual, although it is probable that the onset of thrombosis is in the distal popliteal in contradistinction to cases of thrombosis secondary to atheroma, where the proximal popliteal is initially affected.

3. The differential diagnosis is considered. Most difficulty is encountered in the cases of thrombosis secondary to atheroma, when the latter is extremely localized in the main vessel, and the only arteriographic feature is occlusion. In such cases resection and histological examination of the occluded segment may be the only means of making a certain diagnosis.

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PULMONARY COMPLICATIONS OF PERFORATED PEPTIC ULCER

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IN the course of a study of the post-operative respiratory complications occurring in one general surgical unit during twelve months (1953–4), a high incidence of complications was observed in cases of perforated peptic ulcer. There were 30 cases of perforation distributed as follows :—

Sex.—Male, 24; female, 6.

Age.—20–29 years, 8 (youngest was 20); 30–39 years, 2; 40–49 years, 7; 50–59 years, 9; over 60 years, 4 (oldest was 78).

Treatment.—Conservative, 2 (1 died); simple closure, 26 (2 died); gastrectomy, 2.

With the exception of the 2 patients, both women, who were treated conservatively, all had smoked more than fifteen cigarettes a day for more than a year before perforation occurred.

There were 3 deaths in the series. One woman, aged 68, was admitted moribund forty-eight hours after perforation and survived for only a few hours; she was not submitted to operation. One woman, aged 59, died from cerebral thrombosis on the tenth day; and one man, aged 62, died from coronary thrombosis on the third day after closure of the perforation. The only non-fatal complications were respiratory and they occurred as frequently in young as in elderly patients. These complications have been reviewed particularly in relation to the time of their onset and their response to treatment.

RESPIRATORY LESIONS RECOGNIZED FOR THE FIRST TIME AFTER OPERATION

In the first six months 14 patients underwent operation for perforation. On admission to hospital they had radiographs of the upper abdomen made to demonstrate air under the diaphragm, but the lungs were not examined radiologically and bronchial aspiration was not performed either at or before operation. Seven complications occurred, all examples of pulmonary collapse; one was further complicated by known pre-existing pulmonary tuberculosis under treatment by artificial pneumothorax. After

operation in each instance the lesion was recognized clinically, was confirmed radiographically, and significantly disturbed the patient's convalescence. In 4 cases the collapse was lobar and resisted therapeutic methods short of bronchoscopic aspiration, which had to be performed under local anæsthesia in the first four post-operative days.

Case 1.—A 26-year-old woman was admitted with a story typical of acute perforation of a peptic ulcer. During the second day after simple closure, she complained

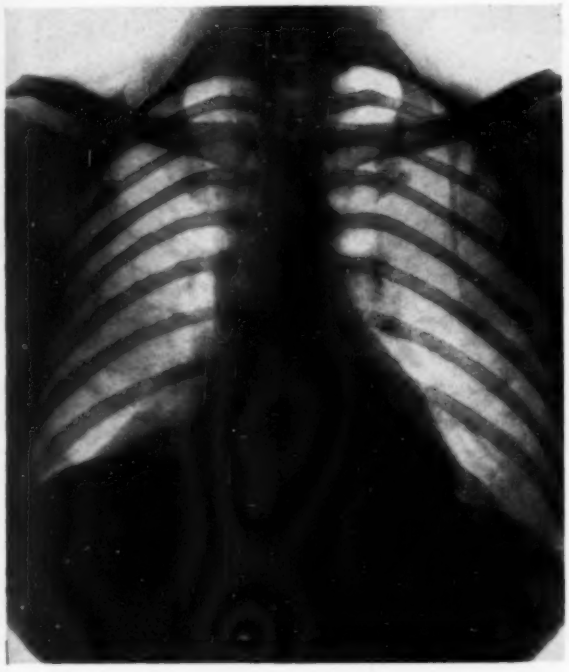

FIG. 409.—*Case* 1. Radiograph demonstrating right lower lobar collapse.

of tightness in the chest and was febrile (102° F.). Before and after operation she had had a moist cough, and now had difficulty in raising her sputum. Clinically and radiographically right lower lobar collapse was demonstrated (*Fig.* 409). On the day after bronchoscopy under local anæsthesia the lobe was fully aerated.

Case 2.—A 20-year-old man was admitted two hours after perforation of a duodenal ulcer; the perforation was closed, and on the following two days he had cough with mucopurulent sputum. On the morning of the third day he became breathless, cyanosed, and anxious, and his temperature rose to 103° F. Collapse of the right middle and lower lobes was demonstrated. He was unable to cough effectively. After aspiration of bronchial secretions through the bronchoscope he was immediately improved and was no longer cyanosed or breathless. The radiograph made two days after bronchoscopy showed clearing of the opacities.

Case 3.—A 54-year-old man was cyanosed and breathless on the morning after simple closure of a perforated prepyloric ulcer. He had a cough which was not obviously moist but was weak and ineffective. Eighteen hours after closure of the perforation, a chest radiograph showed right lower lobar collapse and secretions were aspirated bronchoscopically. On the day after bronchoscopy the right lower lobe was normally aerated and there was patchy collapse of the left lung. By this time he was clinically much improved. The sputum contained a *Staph. aureus* sensitive only to terramycin, which was administered for five days. Seven days after closure of the perforation the chest radiograph was normal and he was transferred to a convalescent hospital.

Case 4.—A 27-year-old man, known to have pulmonary tuberculosis and a left artificial pneumothorax, was admitted with the symptoms and signs of acute perforation of a peptic ulcer. A radiograph of the abdomen was made, demonstrating air under the diaphragm. Lung markings could be seen above the diaphragm on both sides. Within two hours of the first symptom of perforation an anterior duodenal perforation was closed. Next morning

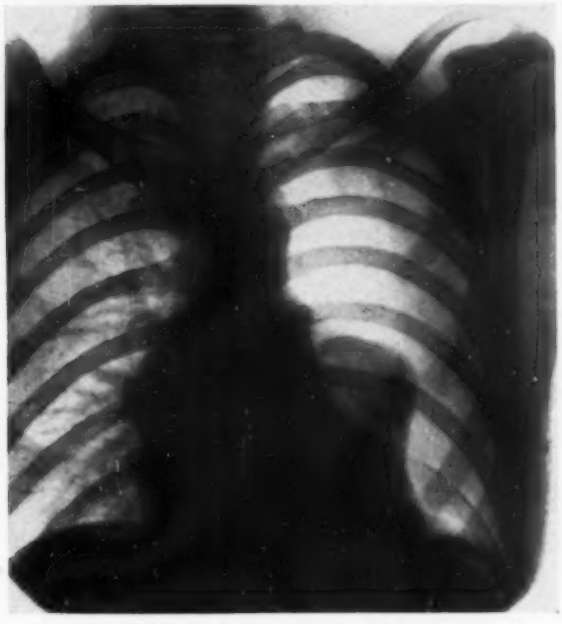

FIG. 410.—*Case* 4. Radiograph showing left lung airless and shrunken against the mediastinum and a large left pneumothorax.

he was well; that afternoon he was observed to be cyanosed, dyspnœic, anxious, and was sitting up in bed to ease his breathing. He maintained that he had been growing more breathless for some hours without any sudden increase in dyspnœa. The chest radiograph made at this time showed the left lung airless and shrunken against the mediastinum and a large left pneumothorax (*Fig.* 410). The bronchi were emptied of secretions by bronchoscopic aspiration, and 1500 ml. of air was withdrawn from the left pleural space. The pleural pressures before withdrawal of air were $-4/-1$ cm. of water and afterwards $-9/-4$ cm. of water. That evening he seemed well, but next day was again slightly cyanosed, cough was ineffective, and the percussion note at the right base was dull. A second radiograph showed the left lung aerated under an adequate left pneumothorax and collapse of the right middle and lower lobes (*Fig.* 411). Bronchoscopy was repeated and much mucopus was aspirated from both stem bronchi. A radiograph on the third post-operative day demonstrated clearing of the atelectasis and an adequate pneumothorax.

After any operation, an artificial pneumothorax tends to be rapidly absorbed. In this instance the pneumothorax gave no further trouble. The likely source of the total pneumothorax was a ruptured pulmonary bulla.

Case 5.—A 68-year-old man had fever (101° F.), some cough and sputum, and right basal crepitations two days

after partial gastrectomy for a second acute duodenal perforation. A chest radiograph showed a patchy opacity in the right lower zone, but no segmental or lobar shrinkage (*Fig.* 412). The sputum contained a *Staph. aureus* sensitive to penicillin. After physiotherapy and the administration of intramuscular penicillin the temperature returned to normal and the sputum reverted to that

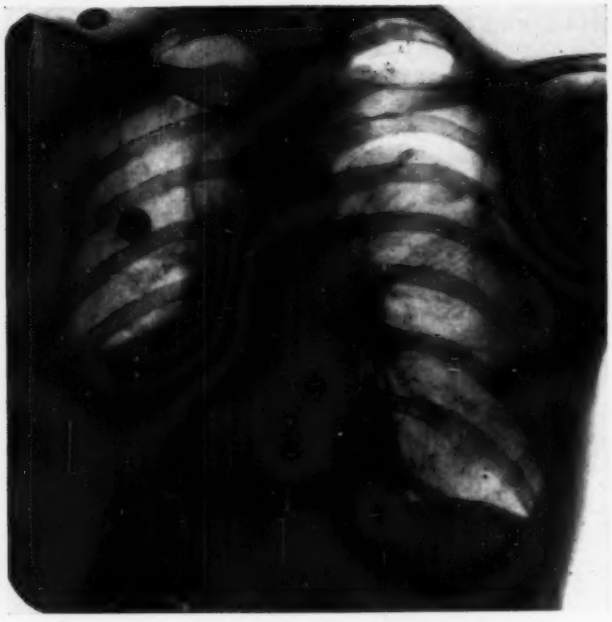

FIG. 411.—*Case* 4. Second radiograph showing left lung aerated under an adequate left pneumothorax and collapse of right middle and lower lobes.

to which he had been accustomed before operation. Forty-eight hours later a radiograph showed clearing of the opacities and his stay in hospital was not prolonged.

Case 6.—Two days after closure of a duodenal perforation in a man of 54, a radiograph showed scattered opacities throughout the right lung and diffuse loss of translucency on the same side. He had very little sputum, which contained only upper respiratory tract commensal organisms. After two more days, during which he had had intramuscular penicillin and physiotherapy, a radiograph of the chest was normal.

Case 7.—Two days after closure of a duodenal perforation in a man of 28, a radiograph of the chest showed patchy right basal collapse without obvious segmental or lobar shrinkage, but with considerable mediastinal displacement. He coughed well, and for three days produced large quantities of purulent sputum, and at the end of that time a radiograph of the chest was normal. There is no record of sputum sensitivity; he received penicillin intramuscularly.

RESPIRATORY LESIONS RECOGNIZED BEFORE OPERATION

In the second six months, 16 patients with perforation of a peptic ulcer were admitted and 14 underwent operation.

It was appreciated that many of the causes of respiratory embarrassment attributed to abdominal operations are, in the case of a perforated peptic ulcer, present before operation. The pain of an acute perforation is more severe than is the pain which is the usual sequel to laparotomy. The consequent immobility of ribs and diaphragm must predispose to pulmonary collapse. The highly irritant gastric juice associated with peptic ulceration

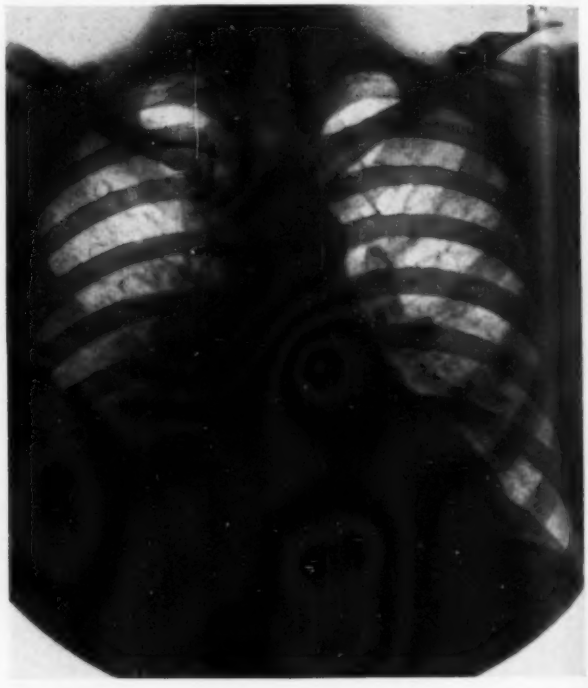

FIG. 412.—*Case* 5. Radiograph showing patchy opacity in right lower zone, but no segmental or lobar shrinkage.

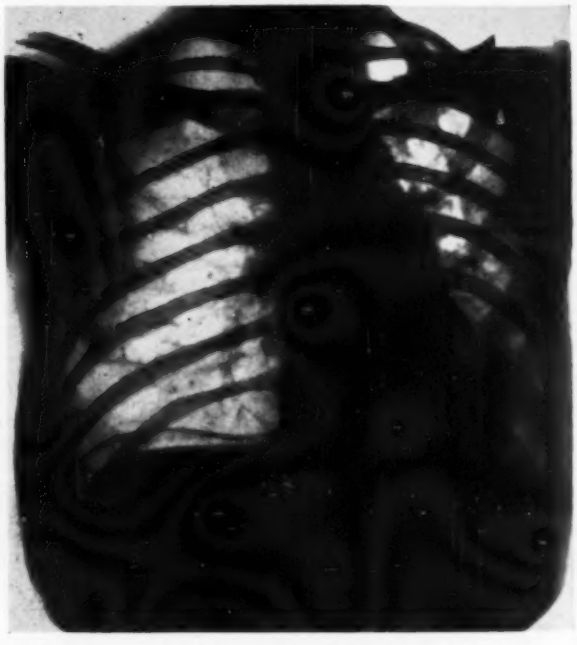

FIG. 413.—*Case* 8. Radiograph made on admission showing patchy collapse of eft lung and a large pneumoperitoneum.

provides a strong stimulus to the parietal peritoneum of the upper abdomen, the receptor field of reflex respiratory inhibition (Nansen, 1950). Finally, the subjects of peptic ulceration are often heavy smokers,

and are therefore likely to have bronchitis at the time of perforation (Morton, 1944).

In the belief that pulmonary collapse might have its origin at the time of perforation and might bear little relation to operation, two changes were made in the routine management of these patients. At the time of admission a postero-anterior radiograph of the chest was made and at the end of the operation, while the patient was still under general anæsthesia,

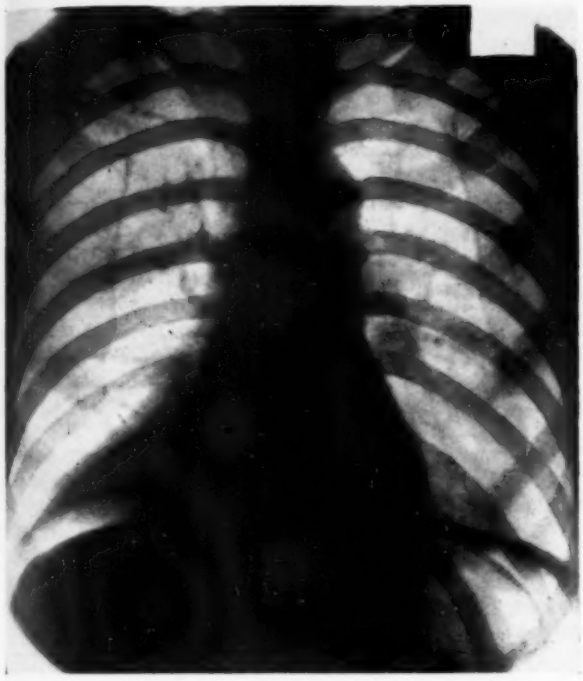

FIG. 414.—*Case* 13. Radiograph made on admission showing a shrunken and airless right lower lobe and a pneumoperitoneum.

the bronchi were emptied of secretions by aspiration through the bronchoscope. No other change was made in the routine management.

Nine of the radiographs showed lobular collapse. Two showed lobar collapse which, at least in one case, had probably not been present before perforation. The maximum interval between perforation and radiography was eight hours. Where a pneumoperitoneum was present, it was clearly seen on the chest radiograph. The apical opacities of previously unsuspected pulmonary tuberculosis were shown in one patient.

At bronchoscopy, in every instance more than 1 ml. of mucopus was collected in the trap attached to the sucker. The purulent character of the secretions was confirmed microscopically. In the patient found to have bilateral apical opacities, the bronchial aspirate was found to contain tubercle bacilli. In only one patient did clinical and radiographic evidence of pulmonary change persist for more than twenty-four hours after operation—a considerable reduction in post-operative pulmonary morbidity in comparison with the preceding six months.

Case 8.—A 29-year-old woman was admitted three hours after the onset of acute abdominal pain. A chest radiograph made on admission showed patchy collapse of the left lung and a large pneumoperitoneum (*Fig.* 413). On the second day after closure of the perforation and post-operative bronchoscopy the pulmonary opacities had cleared.

Case 9.—A 45-year-old man was admitted five hours after perforation of a duodenal ulcer. The pre-operative radiograph of the chest showed clearly the pneumoperitoneum and bilateral patchy pulmonary opacities most marked in the right lower zone. On the day after closure of the perforation the chest radiograph showed complete clearing of the pulmonary opacities and a small residual pneumoperitoneum.

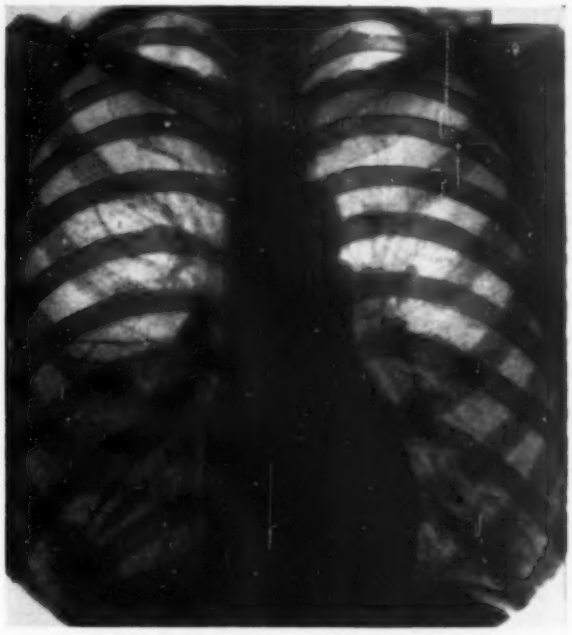

FIG. 415.—*Case* 13. Radiograph made on day after operation showing normal aeration of right lower lobe.

Case 10.—A 56-year-old man admitted three hours after perforation had clinical and radiographic evidence of mediastinal deviation to the right. There was patchy right basal atelectasis. A radiograph made 12 hours after closure of the perforation showed the mediastinum to be central. There was still some basal opacity, but 18 hours later this had cleared. The pre-operative pneumoperitoneum was clearly shown.

Case 11.—The oldest patient in the series, a 78-year-old man, was admitted six hours after perforation. A pre-operative radiograph showed in the right lower zone streaky and patchy shadowing, which was absent in a post-operative radiograph. The pneumoperitoneum was clearly shown.

Three other patients, a woman aged 27 and two men aged 22 and 60, had similar pre-operative radiographic signs and recovered similarly.

Case 12.—A 32-year-old man was admitted four hours after perforation. This was his second perforation, and his ulcer symptoms between perforations had been severe. He was submitted to distal partial gastrectomy. The chest radiograph made on admission showed patchy collapse of the right lung and a pneumoperitoneum. A chest radiograph 24 hours after laparotomy and post-operative bronchoscopy showed clearing of the pulmonary opacities.

Case 13.—A 24-year-old man was admitted four hours after perforation. The chest radiograph made on

admission showed clearly a shrunken and airless right lower lobe and a pneumoperitoneum (*Fig.* 414). This man had had for some years a little morning sputum, attributed to smoking, and no other history of respiratory abnormality. Before induction of anæsthesia his cough was moist. Both before and after closure of the perforation, the bronchi were cleared of secretions by bronchoscopic suction under general anæsthesia. The radiograph made on the day after operation showed normal aeration of the right lower lobe (*Fig.* 415).

Case 14.—A 54-year-old man was admitted eight hours after perforation. For some years he had had cough with about an ounce of greenish sputum in the day.

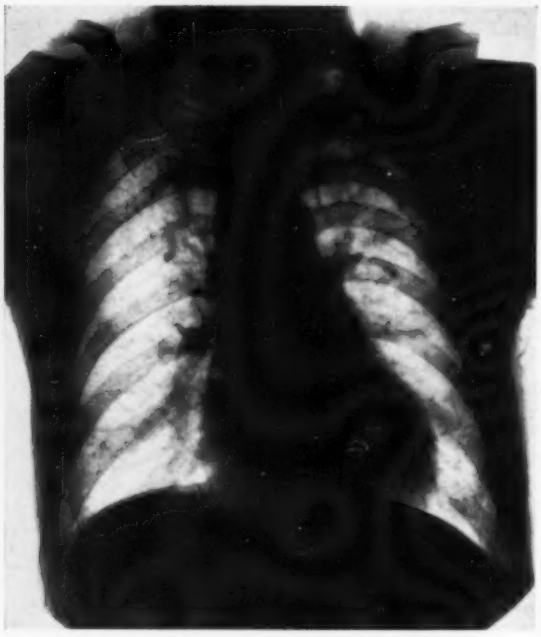

FIG. 416.—*Case* 15. Radiograph showing a pneumoperitoneum and bilateral apical opacities.

The chest radiograph made on admission included only the lower half of his chest, but showed shrunken right middle and lower lobes. There was no visible pneumoperitoneum. At bronchoscopy before and after closure of a very large anterior duodenal perforation, the bronchi were full of mucopus. On the day after operation there was some clearing of the right lower opacity and considerable patchy collapse of the left lung. On the fourth post-operative day, in spite of physiotherapy and intramuscular penicillin, the right middle and lower lobes again collapsed. The bronchi were aspirated under vision three times in the next five days, but these lobes remained shrunken. Fourteen days after operation the chest radiograph was nearly normal, but at this stage he still had numerous right basal crepitations.

It seems likely that this man had bronchiectasis. However, the middle and lower lobes remained aerated for as long as he continued to attend as an out-patient. Six weeks after his discharge from hospital a radiograph of the chest was still nearly normal. He then declined to attend again, and declined further investigation of his respiratory state.

Case 15.—A 45-year-old man with a five-hour history of acute abdominal pain was admitted with the provisional diagnosis of perforated peptic ulcer. The history and clinical examination were suggestive of this diagnosis, but were far from classical. A radiograph of the upper abdomen had been made and this was uninformative. A chest radiograph was made. It showed a pneumoperitoneum, so confirming the diagnosis of perforation of an air-containing intraperitoneal viscus, and in addition, bilateral apical opacities (*Fig.* 416). The secretions aspirated from the bronchi at the end of operation for closure of the perforation contained tubercle bacilli. From the history and from the clinical examination made on admission, there was no reason to suspect that he had pulmonary tuberculosis. One further feature of the pre-operative chest radiograph was an area of collapse in the right lower zone, which was not present in the post-operative radiograph.

CONCLUSIONS

The conclusions which have been drawn from the series presented above are these :—

1. Pulmonary lesions commonly complicate perforation of peptic ulcers.

2. These pulmonary lesions are the consequence of perforation, and not of an operation for its repair. When pulmonary changes are recognized for the first time after operation, they have probably been present, unrecognized, before operation.

3. When a patient admitted to hospital is suspected clinically of having a perforated peptic ulcer, a pre-operative postero-anterior radiograph of the chest with the patient in the erect position should be made for these reasons :—

a. Pulmonary lesions resulting from perforation are demonstrated. The pain of perforation so limits the respiratory excursion that clinical examination of the chest even after sedation of the patient is usually of little value.

b. The presence of a pneumoperitoneum is shown more clearly than by the usual overpenetrated film of the upper abdomen.

c. Coincident pulmonary disease, frequent in ulcer subjects, is discovered at an early stage of the patient's investigation and, with advantage, before operation.

4. The aspiration of bronchial secretions after operation is a valuable prophylactic manœuvre.

5. Pulmonary lesions develop with great rapidity after perforation, especially in those who smoke and who are bronchitic. The mechanism for clearing the bronchi of their abnormal secretions in such patients comes virtually to a standstill at the moment of perforation.

The contention that pulmonary changes complicate perforation, and not an operation undertaken because of perforation, is supported by the high incidence of pulmonary complications of conservatively treated perforated peptic ulcers. In a series of 40 perforations treated in this way (Beattie, 1951), 36 patients survived, and of these 13 had pulmonary complications, most of them right-sided. In the present series there were 15 lesions on the right and 3 on the left. Gill and Jenkins (1950) and Visick (1946) also note the high incidence of pulmonary complications in conservatively treated perforations. Green and Berkowitz (1953) reported a series of cases in which they found collapse or pneumonia complicating acute surgical disease in the abdomen before operation for this acute disturbance had been undertaken. In most of the cases the surgical disease was an abdominal complication which had developed during convalescence from a previous operation. They believed that the occurrence of

pulmonary lesions depended on the presence of bronchitis or of obstructive material within the bronchi during the pre-operative phase of an acute painful abdominal disease when vigorous coughing was prevented by abdominal pain with rigidity of the abdominal wall and diaphragm, abdominal distension, and depression of the cough reflex by drugs. These authors remark that the diagnosis of pre-operative pulmonary lesions is achieved only where their occurrence is expected, and where the examination of the respiratory tract of the patient with a surgical lesion of the abdomen is thorough and includes radiography of the chest.

Pain, especially abdominal pain, is well known to inhibit cough and to limit the respiratory excursion before and after operation. Where bronchial secretions are tenacious or profuse, the cough reflex need be ineffective for only a brief period for collapse to develop. The ciliary mechanism unaided by adequate respiratory excursion and efficient coughing is incapable of expelling these abnormal secretions from the respiratory tract.

The recognition of pulmonary abnormalities before operation on the abdomen is important for several reasons: A pulmonary lesion may increase the difficulty of maintaining optimal ventilation and oxygenation and providing adequate working conditions for the surgeon, especially during an emergency operation on a seriously-ill patient. Pulmonary collapse may increase rapidly during anæsthesia, and cause asphyxia and even death (Green and Berkowitz, 1953). Unless treated vigorously and early, pulmonary collapse of a minor degree is likely to develop into a more severe grade soon after operation, increasing the inconvenience and danger to the patient. Secretions held within a collapsed lobe may be sufficient to infect or obstruct other parts of the lung should they be released suddenly during anæsthesia, especially during its induction.

Many authors emphasize the importance of abdominal sepsis in relation to the development of post-operative pulmonary lesions. Analysing the incidence of pulmonary complications after appendicectomy, King (1933) found this incidence nearly trebled when it was necessary to drain the abdomen, and nearly quadrupled when there was a frank appendix abscess. Brock (1936) reported that 25 per cent of all the pulmonary complications he investigated followed operations for acute appendicitis. It is possible that at least part of the reason for the finding of post-operative pulmonary lesions in these cases of acute inflammatory disease associated with pain, reduction of movement of the abdominal wall and thorax, and suppression of cough is that the pulmonary lesions were present before operation, a consequence of the abdominal lesion and not of the operation undertaken for its cure. An appendix abscess usually takes two or three days to develop. The longer the patient has had to endure abdominal discomfort, and the longer his respiratory excursion and coughing efficiency have been reduced, the more likely are bronchial secretions to have accumulated and produced atelectasis.

The observations made in respect of perforated peptic ulcers are believed to apply to any acute abdominal lesion. Pulmonary collapse so frequently found after an abdominal operation may for the reasons given have been present before operation, and the early evacuation of bronchial secretions is likely to promote a smoother convalescence.

SUMMARY

Pulmonary collapse early in convalescence from perforated peptic ulcer is the result of the perforation and not of the operation for its closure.

Pre-operative radiographs of the chest are useful in demonstrating atelectasis and coincident unsuspected pulmonary lesions. They also clearly show the pneumoperitoneum, if that is required as an aid to diagnosis.

Bronchoscopic aspiration under general anæsthesia at the time of operation is a valuable therapeutic measure.

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CYSTIC DEGENERATION OF THE POPLITEAL ARTERY

By TOR HIERTONN, Stockholm, KAJ LINDBERG, Stockholm, and CHARLES ROB, London

THE purpose of this paper is to describe an abnormality of the popliteal artery which, as far as we know, has not been described in detail before, although a similar abnormality of the external iliac artery was reported in 1946 by Atkins and Key. Our 4 patients were young men complaining of intermittent claudication of sufficient severity to stop them working; in each case the popliteal artery was exposed surgically, a peculiar cystic swelling found which contained jelly, the abnormal segment of artery resected, and continuity restored with a blood-vessel transplant. Microscopical examination showed the main lesion to be a cyst lying within the adventitial layer of the popliteal artery. Our first patient was reported by Ejrup and Hiertonn in 1954.

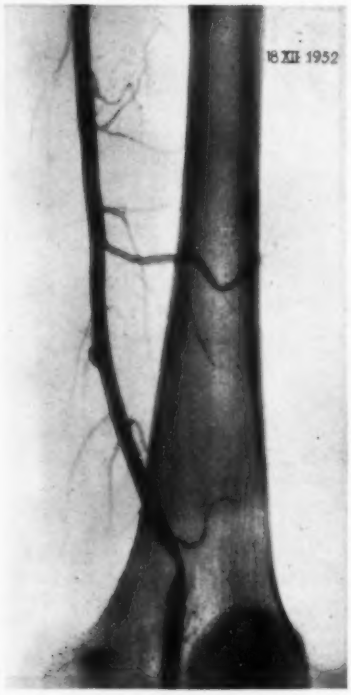


FIG. 417.—*Case* 1. Pre-operative arteriogram. Note the nearly complete occlusion of an otherwise smooth popliteal artery.

CASE REPORT

Case 1.—G. K. H. A., a truck driver aged 32 years, was admitted in January, 1953, to the Orthopædic Clinic of the Karolinska Institute, Stockholm. For six months he had complained of pain in the left knee and calf which at first was not characteristic, but which gradually developed into typical intermittent claudication. The left dorsalis pedis pulse was absent but the posterior tibial was present.

An arteriogram performed on Dec. 18, 1952, demonstrated a stenosing lesion of the popliteal artery about 2 cm. long (*Fig.* 417). The vessel above and below was smooth and apparently normal; the obstruction had an hour-glass appearance. The possibility of an extravascular expansive process compressing the vessel was considered, but at the same time the absence of pathological vascularization was noted.

At Operation (T. Hiertonn, Jan. 12, 1953).—The popliteal artery showed a bluish fusiform enlargement almost to the size of a walnut (*Fig.* 418 A). The vessel was occluded above and below the swelling, which was opened over its centre. Two thimblefuls of a substance resembling raspberry jelly were emptied from an intramural multilocular cavity (*Fig.* 418 B). The affected segment of artery was resected and an autogenous saphenous-vein graft inserted in its place (*Fig.* 418 C).

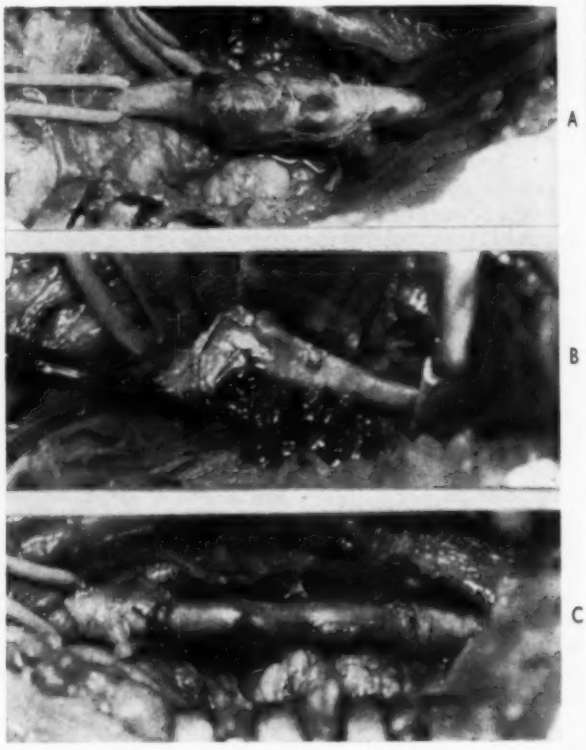


FIG. 418.—A, The popliteal artery of the first patient. This fusiform enlargement was about the size of a walnut. B, An incision into the swelling in the wall of the popliteal artery showed it to be a cyst containing jelly of a light-red colour. C, Shows the autogenous vein graft in position.

The post-operative course was uneventful, both the dorsalis pedis and posterior tibial pulses could be felt. An arteriogram (*Fig.* 419) showed that the graft was satisfactory and this was clinically patent three years later.

Histological examination of the resected specimen showed a large cystic cavity localized to the adventitia (*Fig.* 420). The wall of the cyst showed inflammatory-cell infiltration, some macrophages containing blood-pigment, and in certain areas mucin-containing cells. The other layers of the arterial wall were intact and of normal appearance. In the lumen there was a tiny thrombus at the point where the lumen had been narrowed by the cyst.

Chemical examination of the jelly showed no increase of calcium or cholesterol, but abundant fibrinogen, carbohydrate-rich globulin, and hæmoglobin.

Case 2.—J. M., a general labourer aged 25 years, was admitted to St. Mary's Hospital, London, in March, 1955.

Six weeks previously he had noticed sudden stiffness of the right calf whilst walking on the level. The pain recurred when he had walked a distance of about 100 metres. Later the distance walked before the onset of pain decreased to 50 metres and he was unable to work.

FIG. 419.—*Case* 1. Post-operative arteriogram. An autogenous saphenous vein graft has been inserted and this was clinically patent three years later.

He complained that the right foot felt cold. His other leg was normal and on the advice of his doctor he had stopped smoking soon after the onset of these symptoms.

Both femoral pulses were palpable, the right popliteal, posterior tibial, and dorsalis pedis pulses could not be felt; they were palpable in the left lower limb. An arteriogram (*Fig.* 421 A) showed a segmental occlusion of the popliteal artery about 3 cm. in length. The vessel proximally appeared to be healthy.

AT OPERATION (C. G. Rob, April 7, 1955).—A fusiform pulseless thickening was found in the popliteal artery about 6 cm. long and 2·cm. in diameter at its widest point. The artery was mobilized and occluded proximally and distally. An incision was made into the diseased area when clear jelly-like material similar in appearance to that seen in a ganglion poured out. The lumen of the vessel was found to have been occluded by pressure from the cyst in its wall, the intima being intact. The diseased segment was resected and continuity restored with a freeze-dried homologous arterial transplant (*Fig.* 421 B).

The post-operative course was satisfactory apart from a transitory paralysis of the muscles supplied by the lateral popliteal nerve. When seen six months later both the dorsalis pedis and posterior tibial pulses were easily felt, the nerve lesion had fully recovered, and he was at work.

Examination of the specimen showed a segment of artery in the wall of which was a smooth fusiform cystic swelling containing thick clear yellow mucinous material. Microscopical examination (*Fig.* 422 A, B) showed the cyst to be within the adventitia of the artery, with a partially necrotic media and a normal intima. The lumen of the artery was occluded by compression but not thrombosis. Chemical examination of the jelly showed it to consist principally of a mucoprotein.

Case 3.—L. E. L., a clerk aged 24 years, was admitted to the Orthopædic Clinic of the Karolinska Institute, Stockholm, in June, 1954. He had been fit and well until nine months before, when he suddenly noticed a cramp-like pain in the calf of the left lower limb whilst walking. The pain recurred after he walked about 400 metres. He consulted his doctor, who prescribed Priscol. He also noticed that his left foot was colder than the right

The femoral pulses were palpable; the left popliteal posterior tibial and dorsalis pedis pulses could not be felt

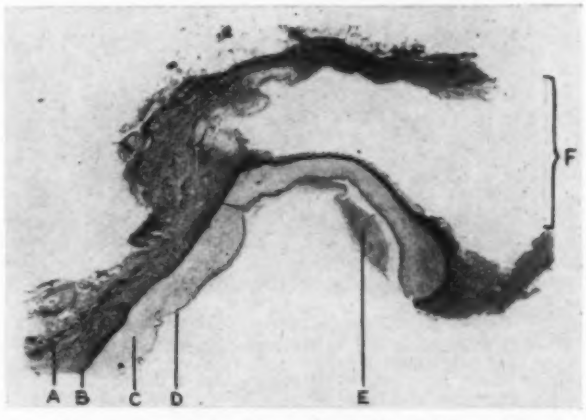


FIG. 420.—*Case* 1. Photomicrograph of the specimen. A, Adventitia; B, External elastic lamina; C, Media; D, Intima; E, Incipient thrombosis; F, Cyst in the adventitia.

—they were palpable on the right side. An arteriogram showed a normal arterial tree on the right side, but on the left (*Fig.* 423 A, B) there was a segmental occlusion of the popliteal artery with a probably healthy femoral artery proximally and a good popliteal artery distally.

AT OPERATION (T. Hiertonn, June 11, 1954).—The popliteal artery was exposed and a fusiform bluish

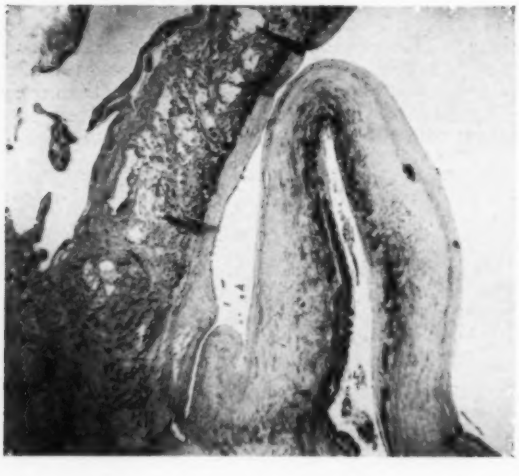
A B

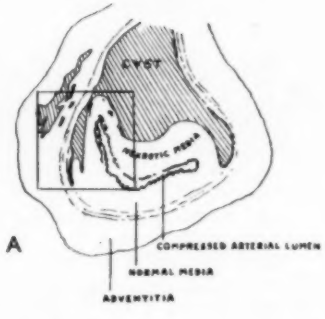
FIG. 421.—*Case* 2. A, B, Arteriograms before and after reconstruction with a homologous arterial transplant. In this patient the arteriogram showed a complete occlusion of the popliteal artery, although the intima was found at operation to be normal and intact.

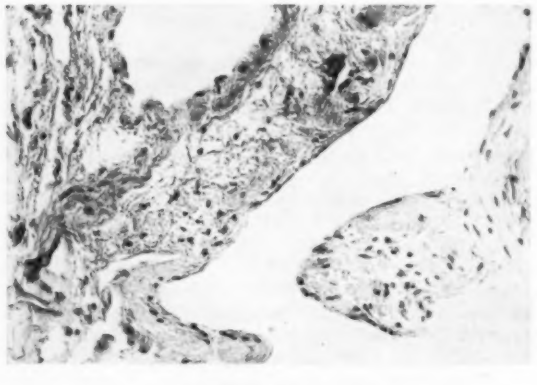
external elastic lamina. Microscopical examination of the artery proximal to the cyst showed medial calcification and intimal thickening. The vessel at this level showed evidence of recanalization of a thrombus (*Fig.* 424 A, B). In the region of the cyst there was a sharp break in the continuity of the arterial wall. This break was considered to be probably a rupture, communicating with the cyst which lay in the adventitia. In the distal half of the specimen a double lumen had been developed (*Fig.* 425 A, B).

The patient's post-operative course was satisfactory and when seen in May, 1956, he was at work and all the peripheral pulses were palpable.

Case 4.—This patient, a heavy worker aged 32 years, complained of intermittent claudication of only four months' duration; the onset had been fairly sudden but not acute. Arteriography revealed a segmental occlusion of the popliteal artery with good contrast filling above and below. At the operation (Hiertonn) the occluded segment was resected and replaced by an autogenous vein graft sutured end-to-end to the popliteal artery. The specimen looked like a sausage and was 7 cm. in length. The lumen was compressed by an intramural cyst containing jelly under high tension. The pathological report (K. Lindberg) revealed that the cyst was situated, as in the other three specimens, within the adventitia and outside the media of the artery. The post-operative course was uneventful. The patient's intermittent claudication disappeared and he has palpable ankle pulses.







B

FIG. 422.—*Case* 2. A, Photomicrograph (low magnification) and schematic drawing of the specimen. Note the cyst lying within the adventitia outside the area of medial necrosis. B, High magnification of the cyst wall. Note its lining by flattened cells and the myxomatous structure.

thickening of the artery found which extended over about 9 cm. of its length. There was marked periarteritis and the dissection was difficult to perform. The diseased segment of artery was resected and an autogenous vein graft inserted.

Examination of the specimen showed a cyst containing jelly-like material of similar appearance to that already described lying in the wall of the artery outside the

DISCUSSION

Each of our four patients had a cyst localized to the adventitial layer of the popliteal artery and each appears to have been removed surgically at a different

FIG. 423.—*Case* 3. A, B, Pre- and post-operative arteriograms from the third patient.

stage in the development of this lesion. *Case* 1 shows the cyst with a normal media, stenosis of the lumen of the artery by pressure, and an intima which was normal apart from a tiny mural thrombus. *Case* 2 shows a similar cyst within the adventitial layer but the media is partially necrotic. In *Case* 3 the process has developed still further, with rupture of the necrotic media and of the intima forming a communication between the adventitial cyst and the arterial lumen.

We find it difficult to assign a cause to this lesion. To the naked eye it resembles a ganglion and the lesion appears to be an intramural mucinous degeneration of this type, there being no evidence that the cause is inflammation or old hæmorrhage. It is possible that the repeated minor trauma which may be inflicted on the femoro-popliteal as it passes beneath tendinous bands such as the adductor hiatus may be a contributory factor. The cyst walls were lined by flattened cells which were probably altered by pressure, although they resembled endothelium. Cystic lesions have been noted in the media of arteries (Erdheim, 1930), but in our patients the lesion lies in the adventitia and appears to differ in many ways from this form of cystic medial necrosis.

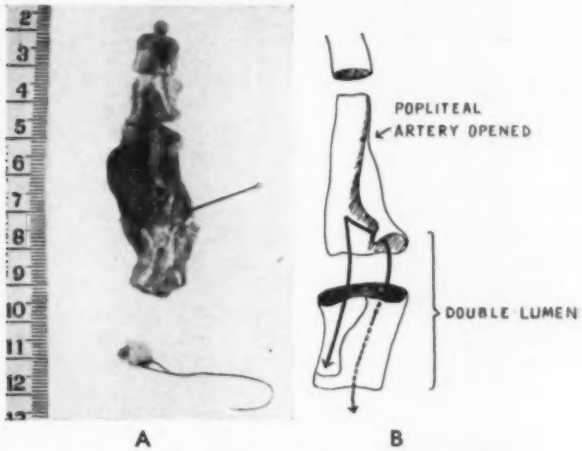


FIG. 424.—*Case* 3. A, B, Specimen removed. Note the jelly-like material and the double lumen. The diagram explains our interpretation of the findings.

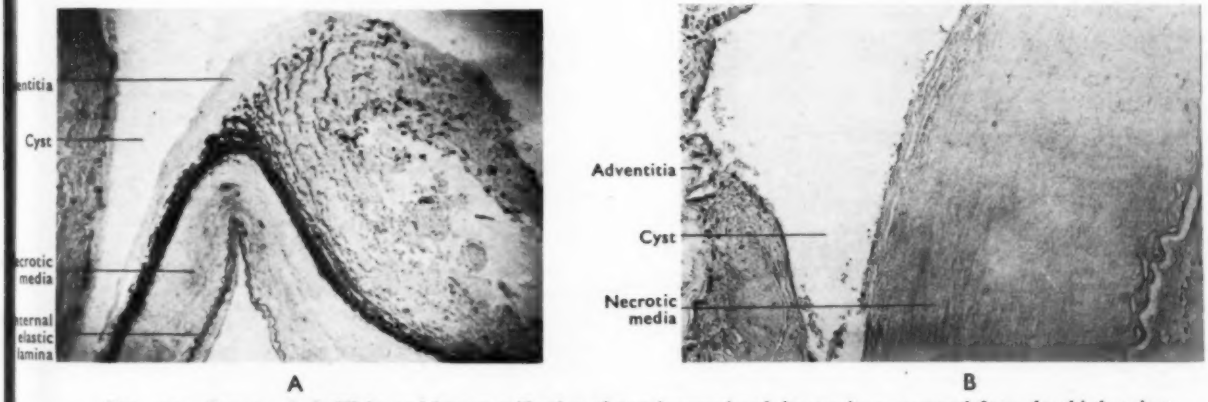


FIG. 425.—*Case* 3. A, B, High- and low-magnification photomicrographs of the specimen removed from the third patient. Note that the internal elastic lamina is well preserved. The media is œdematous and necrotic. A cyst is present outside the external elastic lamina; it is lined with flattened cells and surrounded by fibrous tissue, œdematous but without any smooth-muscle fibres.

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THE PATHOLOGICAL ANATOMY AND TREATMENT OF PAROTID TUMOURS WITH RETROPHARYNGEAL EXTENSION (DUMB-BELL TUMOURS)

WITH A REPORT OF 4 PERSONAL CASES

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MOST tumours of the parotid arise superficial to the facial nerve, for the obvious reason that there is more parotid tissue from which they can arise superficial than deep to the facial nerve. Of the tumours which arise deeply, only a small proportion develop a retropharyngeal extension. The tumours under discussion are therefore rare, and the number seen by any one surgeon small. As a result, they seem largely to have escaped systematic study. Proby (1924) was only able to collect and report 4 cases from the literature up to this date, all of which had been treated by removal from the pharynx, and he states that: " Il est difficile de donner une technique bien réglée de l'intervention." Among the few other papers is one by Leriche (1935) in which he described a " new pre-digastric incision for removal of enucleable tumours of the pharyngeal prolongation of the parotid gland " and reported 1 case. During the past few years, owing to the kindness of colleagues in referring cases to us, we have had the opportunity of treating and studying 4 cases, which constitutes an unusually large personal experience. We therefore thought that an account of the special features and problems presented by these cases together with our conclusions on treatment would be of some general interest.

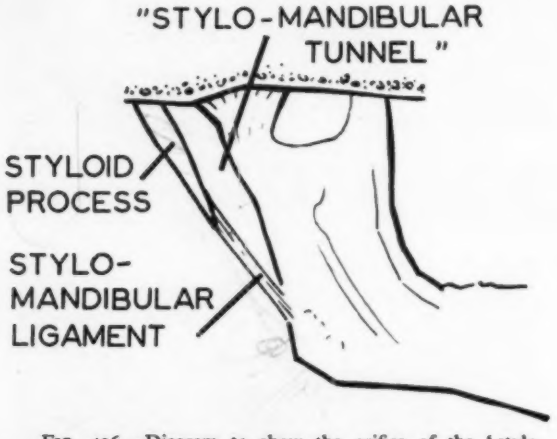

FIG. 426.—Diagram to show the orifice of the 'stylomandibular tunnel' through which the pharyngeal extension of a parotid tumour has to pass.

PATHOLOGICAL ANATOMY

It is usual to describe a small pharyngeal projection as a normal extension from the deep surface of the parotid gland, though Jefferson and Platt (1912) could find no gross anatomical extension, and this agrees with our own experience. There is also a difference of opinion on whether the postulated extension represents a protrusion through a deficiency of the parotid capsule or not (Grégoire, 1912). But certainly from the point of view of pathological anatomy, it is a question of a tumour starting in the deep portion of the parotid and extending into the retropharyngeal region, rather than a

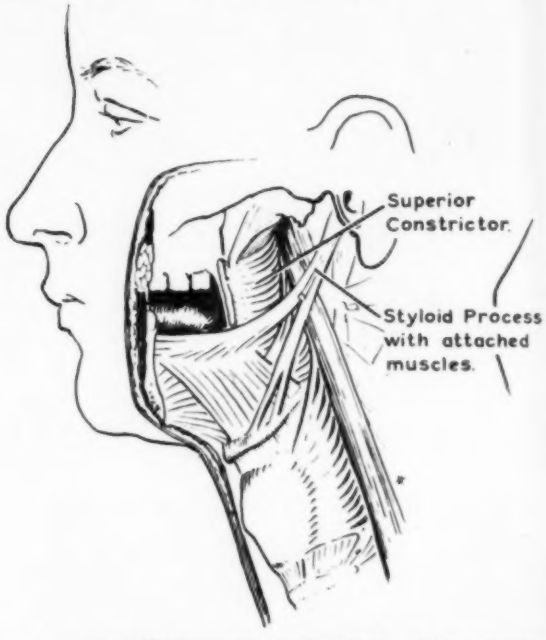

FIG. 427.—Diagrammatic representation of the 'parotid mould' in which the parotid gland lies, after the lower jaw has been removed. It will be seen that a pharyngeal extension of a parotid tumour after passing through the 'stylomandibular tunnel' will impinge on the superior constrictor of the pharynx.

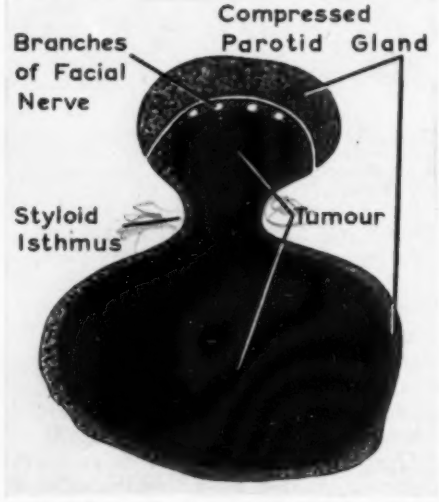

FIG. 428.—Diagram to show the typical dumb-bell structure of a parotid tumour with pharyngeal extension. The facial nerve and its branches are pushed well outward to be separated from the skin by only a layer of compressed parotid tissue.

tumour starting in a retropharyngeal extension, a point of practical importance if operative removal by the pharyngeal route is being considered.

FIG. 429.—Anterior view of patient (*Case* 4), showing the degree of submaxillary extension of the tumour.

FIG. 430.—Same case, lateral view.

For the channel by which the tumour passes into the retropharyngeal region, we have coined the term 'stylomandibular tunnel'. The opening of this tunnel is formed by the base of the skull above, the ascending ramus of the jaw and internal pterygoid muscle in front, and the styloid process and stylomandibular ligament behind (*Fig.* 426). On a deeper plane, the tunnel enlarges and is bounded by the superior constrictor of the pharynx in front, and the styloid process and styloglossus, and stylopharyngeus muscles behind (*Fig.* 427). Since the opening of the tunnel is only extensible to the extent that the styloid process can be distorted and the stylomandibular ligament stretched, a tumour beginning in the deep portion of the parotid and extending retropharyngeally tends to be constricted and fixed at this relatively inextensible opening. The complete tumour when well developed thus tends to assume the shape of a dumb-bell, hence the alternative name of 'dumb-bell tumour' which we have used (*Fig.* 428). An important practical result of such dumb-belling when marked is that it is impossible to deliver without rupture either part of the tumour through the stylomandibular opening.

FIG. 431.—Same case to show gross bulging of palate and pharynx on right side. The uvula is in contact with the left anterior pillar of the fauces.

CLINICAL FEATURES

A small retropharyngeal extension may not be diagnosed clinically, but be found only on routine exploration of a parotid tumour (*Case* 3). On the other hand, the parotid portion of the swelling may not be noted, and the patient present because of the pharyngeal extension. This causes a bulge on the affected side, chiefly of the soft palate and tonsillar region. Since the pharyngeal extension may not be associated with any symptoms until the tumour reaches a large size, the condition may only be discovered incidentally. Thus in *Case* 1 the patient had a simple sore throat for which she went to her doctor. The bulging of the palate and tonsillar region was then for the first time noted, and a diagnosis

of peritonsillar abscess made. The possibility of tumour was not thought of until after a negative incision of the apparent abscess. In other cases (*Cases* 2 and 4) both the parotid and pharyngeal swellings may be noted at about the same time (*Figs.* 429–431). In both these cases the pharyngeal bulge caused moderately severe symptoms ; in *Case* 2 a constant feeling of something sticking in the throat and an inability to retain the upper dentures, and in *Case* 4 actual difficulty in swallowing. In *Case* 3 the patient's main symptom was a neuralgic type of pain in the distribution of the inferior division of the fifth cranial nerve, and it is possible that this was due to direct pressure on the nerve by the tumour since it has cleared up since operation.

DIAGNOSIS

Tumours arising in the deep portion of the parotid with pharyngeal extension as their main feature have to be distinguished from similar tumours arising primarily in the mucous glands of the pharynx (Ranger, Thackray, and Lucas, 1956). This may be difficult, but the fact that a tumour can also be felt in the parotid region, which on bimanual palpation can be ballotted between the external and internal examining fingers, makes the diagnosis of a parotid origin almost certain (*Cases* 1, 2, 4). The diagnosis of the exact nature of the tumour, as with parotid tumours in general, is not definitely establishable clinically, though most are mixed tumours (*Cases* 1, 2, 4). But only the microscope can decide, as is illustrated by *Case* 3, in which the tumour proved to be a neurinoma. The question arises of the diagnostic removal of a small piece through the palate, which was in fact performed in two of our cases (*Cases* 1 and 2). In *Case* 1, in which the tumour was subsequently removed by a combined pharyngeal and external approach, this preliminary exploration caused no difficulty. But in *Case* 2, in which the whole tumour with the parotid was subsequently removed by an external approach alone, the separation of the tumour from its adhesion to the site on the palate at which the biopsy incision had been made did give rise to difficulty, and we would advise therefore that biopsy is not performed if the approach we recommend is to be used. In *Case* 3 we did not, unfortunately, examine the fauces and are therefore unable to state whether there was a palatal bulge or not, though from the size of the tumour it is almost certain that there was ; and in any case the pharyngeal tumour must have been palpable if bimanual palpation had been carried out. And since to be forewarned is to be forearmed, we feel that the lesson of this case is that the fauces of all cases of apparently deep-seated tumours in the parotid should be examined as a routine, both visually and by bimanual palpation, in order to exclude retropharyngeal extension.

DIFFERENTIAL DIAGNOSIS

As with parotid tumours without pharyngeal extension, the possibility of pathological conditions of the parotid lymph-nodes should be considered in the differential diagnosis, and we have in fact had one case referred to us with marked parotid and pharyngeal bulging, which proved on investigation to be a case of lymphatic leukæmia with localization of the glandular enlargement to the parotid lymph-nodes. Carcinoma of the parotid may of course spread to the retropharyngeal region, but by the time it has done so there may be signs of infiltration, particularly of the nerves emerging from the foramina of the base of the skull, and the whole clinical picture is different, since carcinoma does not observe anatomical boundaries.

PATHOLOGY

These 4 tumours of the parotid have been brought together on account of their similar position rather than because of any histological resemblances. Of the considerable variety of tumours that develop in the parotid gland, the commonest being the so-called ' mixed parotid tumour ', any may presumably on occasion arise in the deep portion of the gland and extend in the direction of the pharynx. There is no reason to suppose that any one histological type of parotid tumour is more likely to develop in the deep part of the gland. Of the 4 cases reported here, 3 were mixed parotid tumours, whilst 1 was a neurinoma. The latter is an uncommon finding in the parotid, but small nerves are often seen in the substance of the gland quite apart from the main branches of the facial nerve, and presumably it is from one of these that this nerve-sheath tumour arose.

TREATMENT

As with parotid tumours in general, the only effective treatment is surgical removal. If the external tumour is in the lower pole of the parotid and if there is a good plane of cleavage, enucleation is feasible, either by a purely external, a purely internal, or a combined interno-external approach, as in *Case* 1. But enucleation of parotid tumours is being abandoned in favour of parotidectomy as an anatomically and pathologically sounder operation. And if this is so for parotid tumours confined to the parotid, it should also apply for those with retropharyngeal extension. But apart from this, there are other considerations. Thus, if the tumour arises high up from the posterior part of the parotid, the facial nerve will be stretched over its antero-inferior aspect and it will probably be impossible to get access from below for enucleation without injury to the facial nerve. And again if dumb-belling of the tumour is marked, it will be impossible, as already noted, to deliver it through the orifice of the stylomandibular tunnel without rupture. For all these reasons, and in spite of the good result obtained in *Case* 1, we feel that parotidectomy should be the treatment of parotid tumours with pharyngeal extension as of parotid tumours in general. The technique of parotidectomy with preservation of the facial nerve is now well established and several recent accounts are available (Redon, 1955 ; Patey, 1954, and in publication ; and Ross, 1955). We will therefore confine ourselves here to the special points of technique presented by tumours with retropharyngeal extension.

Recommended Technique.—After the usual wide exposure, the trunk of the facial nerve is identified as it emerges from the stylomastoid foramen, remembering that in these cases it will be stretched superficially over the tumour arising

in the subfacial part of the parotid. The superfacial* part of the parotid, which may be very thin and stretched, is resected as the facial nerve and its branches are dissected out. The facial nerve and its branches are now freed from the underlying tumour and gently raised on a thin strip of latex rubber. And now comes the essential special step of the operation. The normally situated deep part of the parotid and the pharyngeal extension, both of which are in these cases largely represented by tumour, are in our experience easily freed from surrounding structures, but they are tightly gripped at their junction by the styloid process and the stylomandibular ligament. In our first two cases we had considerable difficulty in delivering the tumour because of this, and in the second the tumour ruptured during delivery. It was because of this experience that we undertook a more detailed study of the anatomy, and the obvious answer to the problem soon emerged—to divide the constriction. At first we thought it would be best to divide the styloid process at its base with a bone forceps, and to turn it forwards with its attached ligaments and muscles, but, on starting to carry this out in *Case* 3, we found that mere division of the styloid was enough. The risk of injuring the facial nerve made us anxious about cutting with bone forceps so close to its emergence from the stylomastoid foramen, so in our last case (*Case* 4) we found what we think is the ideal procedure—to divide the stylomandibular ligament with scissors and then to fracture the styloid process by gently inserting a blunt hook around it and giving a sharp tug backwards. Once this has been done, both the normally situated deep portion of the parotid and the pharyngeal extension are, after ligature and division of the internal maxillary artery, readily freed and removed. In fact, the leverage provided by being able to hold the pharyngeal extension may make removal of the deep portion of the gland appreciably easier than in cases in which the anatomy is normal.

CASE REPORTS

Case 1.—Mrs. M., aged 40 years (B.75389).

In February, 1949, the patient attended at the Ear, Nose, and Throat Out-patient Department with a history that one month previously she had had a sore throat for which she had gone to the doctor. He found a large swelling pushing down the soft palate on the right side which he diagnosed as a peritonsillar abscess and incised. No pus was obtained, and, as the condition continued unchanged after a course of penicillin, he referred her for further advice.

On examination by Mr. J. P. Monkhouse, a firm smooth swelling was observed on the right side of the fauces extending from the eustachian tube above down to the lower pole of the tonsil below, and pushing the right lateral wall of the nasopharynx and the soft palate and tonsil towards the middle line. The swelling was estimated to be about the size of a walnut, and was continuous with another swelling that could be palpated in the neck at the level of the lower pole of the parotid, but which was not causing any gross external projection. An incision was made through the palate and an encapsulated firm tumour found, biopsy of which was reported on as a mixed tumour of parotid type. Radiography showed a large soft-tissue shadow obscuring the right side of the base of the skull. A suggestion of bone destruction was not confirmed by a tomogram. A course of deep X-ray therapy was given to the tumour, 5400 r being given from the external aspect, and 1000 r intrabuccally. Following this treatment, the parotid part of the swelling 'regressed considerably', but the palatal swelling to a much smaller extent.

On May 19, the tumour was explored by a combined external and internal approach. An oblique skin-crease incision was made on the right side of the neck and the external carotid artery was ligated just below the level of the digastric. The external portion of the tumour, which was in the region of the lower pole of the parotid, was freed, a good plane of cleavage between the tumour and surrounding structures being found. There was a slight narrowing between the external portion of the tumour and its retropharyngeal extension. An incision was next made in the soft palate and the retropharyngeal portion of the tumour freed, and, after further combined external and internal dissection towards the lower pole, both portions of the tumour were completely freed. Up till this point the operation was simple and uneventful. The final delivery of the freed tumour presented some difficulty owing to its dumb-bell shape and its being gripped at the isthmus. Eventually the external portion, which was slightly the smaller, was pushed through the constriction at the isthmus and the tumour delivered through the mouth. The palatal wound was sewn up and the external wound closed with stab drainage. Both wounds healed soundly and the patient made an uneventful recovery. She has to date (seven years) had no further trouble related to the tumour.

PATHOLOGY.—The operation specimen consisted of an enucleated firm ellipsoid tumour with a slightly nodular surface and a definite, but not deep, constriction a little nearer one pole than the other. On section it was for the most part firm, opaque, and white, but with occasional small cysts and areas of 'cartilaginous' appearance.

Microscopically the growth was a typical mixed parotid tumour, the epithelial cells in many areas forming well-marked tubules and occasionally small cysts.

Case 2.—Mrs. F., aged 39 years (H.79269).

In December, 1954, the patient went to her local hospital because of a constant feeling as if something had stuck in her throat and an inability to wear her upper dentures. She had also for a few months noticed a slight swelling in her left parotid region, but she had paid no attention to this. She looked at her throat and noticed a marked bulging inwards on the left side. At the hospital a biopsy of the swelling of the throat was performed under general anæsthesia, and the diagnosis of mixed tumour of parotid type was made. She was subsequently transferred to the Middlesex Hospital.

On examination, she was a healthy woman with nothing of note apart from the local swelling. In the lower part of the left parotid region there was a firm swelling about 1½ in. in diameter, deeply fixed, not projecting noticeably above the normal skin level, and only slightly mobile. On inspection of the fauces, the left side of the soft palate with the left tonsil and the left side of the fauces formed a prominent bulge towards the middle line and the uvula was well pushed over to the right. On palpation, a firm swelling could be felt deep to the soft palate, which could be established by ballottement as being continuous with the external parotid swelling.

On Jan. 3, 1955, the left parotid was widely exposed from the neck by an S-shaped incision, the upper part of which ran vertically in the pre-aural skin crease, and the lower obliquely in the upper skin crease of the neck, the two being joined by a curved incision over the mastoid and upper end of the sternomastoid. The facial nerve was found stretched over a tumour arising in the inferior

* In this paper, the term 'superfacial parotid' will be used for that part of the parotid superficial to the plane of the facial nerve, and 'subfacial parotid' for that part deep to the plane of the nerve.

part of the deep portion of the parotid gland with the result that the nerve described a marked convexity towards the surface and cranially. The facial nerve and its branches were traced out by splitting the parotid gland in the plane of the nerve, and the part of the parotid superficial to the nerve was removed. The nerve was then lifted up and the deep portion of the parotid freed.

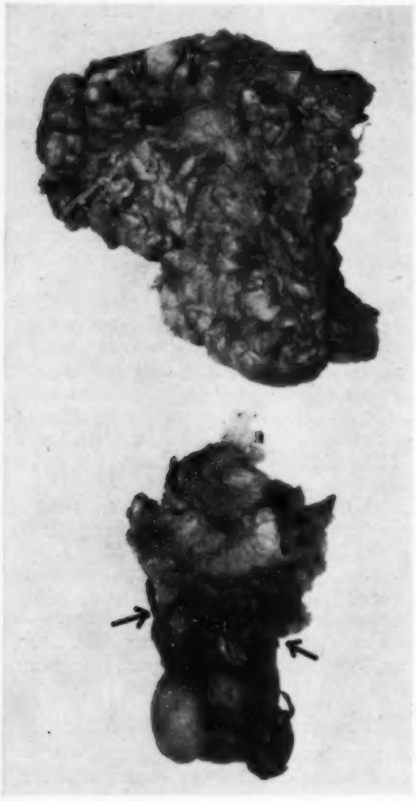

FIG. 432.—Specimen from *Case* 3 (⅔ life size). Above is the superfacial part of the parotid, below the subfacial. The tumour occupied the latter part, and also projected deeply from the subfacial parotid. Arrows indicate the slight constriction caused by the orifice of the stylomandibular tunnel.

The tumour arising in this deep portion was connected by a narrow isthmus with the retropharyngeal extension. The latter was readily freed from the pharyngeal wall except for some difficulty with adhesions at the site of the palatal biopsy. But great difficulty was experienced in delivering the pharyngeal extension of the tumour owing to the tightness with which it was gripped at the isthmus by the boundaries of the stylomandibular tunnel. And during the final delivery the retropharyngeal extension of the tumour unfortunately ruptured. The wound was irrigated and all loose tumour tissue apparently completely removed, and the skin closed with stab drainage. Healing of the wound was uneventful. There was slight weakness of the angle of the mouth, but otherwise no facial palsy. In view of the possibility of implantation recurrence at the time of rupture of the tumour, a post-operative course of deep X-ray therapy was given by a convergent beam unit, the total depth dose being estimated at 6500. The patient made an uninterrupted recovery, the slight facial weakness rapidly recovering, and she has remained well and free from further trouble.

PATHOLOGY.—The specimen consisted of a dumb-bell shaped tumour 2½ in. long, with a cap of normal parotid tissue superficially. The deep part of the dumb-bell had ruptured and there were several separate fragments of tumour tissue up to ½ in. long. When cut across, this deep part of the tumour appeared soft and almost mucoid, only in parts approaching the consistence of cartilage.

Microscopical sections showed a mixed salivary-gland tumour with strands and columns of epithelial cells, in places forming tubular structures, with a considerable amount of intercellular mucoid or pseudo-cartilaginous material.

Case 3.—Mr. G., aged 70 years (P.P.4384).

For about nine or ten years the patient had noticed a swelling in the position of the left parotid gland associated with pain, sometimes shooting up to the left temporal region, and on occasions with trismus. At the beginning of 1954 he consulted Mr. Anthony Till, who found a diffuse swelling in the left parotid gland, and a diagnosis of chronic parotitis was tentatively made. Sialography, however, was negative. A course of deep X-ray therapy was given without effect either on the swelling or the pain. More recently the pain had become more marked and more persistent, and the swelling had increased a little in size. Apart from a prostatectomy twelve years previously there was nothing of note in the previous history.

On examination the patient was a healthy looking, well-covered man with a ruddy complexion. There was a diffuse prominence of the left parotid with a suggestion of a deep-seated more localized lump. On April 20, 1956, sialography was performed by Dr. J. N. Pattinson, which showed no evidence of parotitis but a suggestion of a deep-seated filling defect.

On June 7, exploration of the left parotid was undertaken. The parotid was explored by a large S-shaped incision as in *Case* 2. The main trunk of the facial nerve was identified and found to be stretched over a tumour arising in the deep part of the parotid gland. The superfacial part of the gland was removed, and after elevation of the facial nerve and its branches, the subfacial part of the gland was freed. It was then found that the tumour arose from the deep aspect of the subfacial parotid and extended through the stylomandibular tunnel to form a retropharyngeal extension, which could not be delivered through the isthmus. The styloid process was therefore divided almost two-thirds of the way along towards its base, and the constriction was at once relieved. The retropharyngeal extension was now easily freed and delivered, and removed together with the rest of the subfacial part of the parotid gland. A certain amount of stretching of the facial nerve occurred during the freeing of the tumour and deep portion of the gland, though complete anatomical preservation of the nerve and its branches was achieved. A complete facial paralysis with reaction of degeneration developed after the operation and the patient was treated by galvanism pending regeneration of the nerve to the facial muscles. The pain of which he complained before operation disappeared immediately and recovery of facial movement has now begun.

PATHOLOGY.—The operation specimen consisted of a normal-looking superfacial portion of the parotid gland, approximately in the shape of a flattened equilateral triangle with sides 2½ in. long, and also the deep portion of the gland containing, projecting from its deep aspect, a markedly lobulated soft white tumour 1½ in. in its greatest length (*Fig.* 432). On section the lobes of the tumour were composed of greyish-white tissue with central areas of cystic degeneration surrounded by a bright golden zone.

Microscopically the appearances were those of a neurinoma with areas of fatty degeneration.

Case 4.—Mrs. S., aged 38 years (K.7717).

For four years she had noted swellings which had appeared about the same time in the right parotid region and the right palate. They gradually increased in size

and operation was advised on a number of occasions but the patient refused. Eventually, by the middle of 1956, difficulty in swallowing became marked and she had to go through the motions of swallowing two or three times before the food would go down. She was now anxious to have treatment. She was referred to Dr. J. S. Fulton,

FIG. 433.—Specimen from *Case* 4 (⅓ life size). Above and separate is the small stretched out, but otherwise normal, superfacial parotid. Below is the large tumour starting in and almost entirely replacing the subfacial parotid. The exaggerated dumb-bell shape of the tumour is striking (arrows indicate the site of the constriction caused by the orifice of the stylomandibular tunnel). The part above the arrows corresponds to the tumour visible and palpable in the neck, the part below to the pharyngeal extension. The part above and to the right of the right arrow corresponds to the submaxillary extension of the tumour.

at the Liverpool Radium Institute, but he advised that radiotherapy was unlikely to help and referred her for surgery.

On examination (*Figs.* 429-432) there was a large, soft, lobulated swelling in the position of the right parotid gland with similar soft, lobulated masses extending well into the right submaxillary region. On examination of the fauces there was a similar soft mass continuous with the external masses causing marked bulging of the right side of the soft palate and associated tonsillar region and extending also well down into the pharynx. The uvula was pushed over to the opposite side.

On Aug. 3, a total parotidectomy was performed by a similar technique to that employed in *Cases* 2 and 3. When the superfacial portion of the parotid had been removed and the preserved facial nerve and its branches lifted up on a strip of latex rubber, the firmly wedged deep dumb-bell-shaped tumour was freed by dividing the stylomandibular ligament and fracturing the base of the styloid process. The tumour and thinned-out deep portion of the parotid gland were then readily removed. There was only slight facial weakness after the operation, and the patient made a rapid and uneventful recovery. All pharyngeal symptoms disappeared, and the appearance of the fauces returned to normal immediately the tumour had been removed.

PATHOLOGY.—The specimen consisted of a flattened piece of apparently normal parotid tissue $2 \times 1\frac{1}{2} \times \frac{1}{2}$ in., and also a firm irregularly lobulated tumour. A deep constriction divided the tumour into a larger superficial part $3 \times 2\frac{1}{2} \times 2$ in. and a smaller deep part $2\frac{1}{2} \times 2 \times 1\frac{1}{2}$ in., leaving only a neck $\frac{1}{2}$ in. across connecting the two

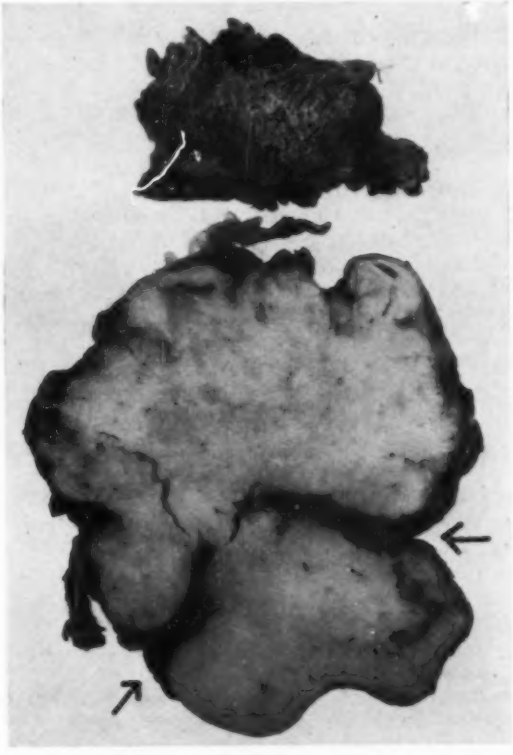

FIG. 434.—Cut section of specimen from *Case* 4 (⅓ life size). Again, the separate piece of tissue at the top is the normal superfacial parotid. Below is the dumb-bell tumour. It will be noted that the isthmus is even narrower than appears on the uncut specimen. (The splits in the white tumour tissue above and to the left of the isthmus are artefacts.)

portions (*Figs.* 433, 434). When cut across the tumour was seen to be firm and white with scattered cartilage-like areas. Microscopically it proved to be a typical mixed parotid tumour.

CONCLUSIONS

These 4 cases represent the gradual development over the years of our ideas on the treatment of parotid tumours with pharyngeal extension, the development being a slow one owing to the rarity of the condition. We may summarize our main conclusions as follows :—

1. A routine examination of the pharynx, including bimanual palpation, is advisable in all cases of apparently deeply situated parotid tumour if retropharyngeal extensions are not to be missed.

2. Parotidectomy with preservation of the facial nerve should replace enucleation for these tumours as for parotid tumours in general.

3. Removal is best carried out by a wide external approach and a pharyngeal approach is unnecessary and undesirable. A transpharyngeal biopsy should also be avoided.

4. The key to the technique of parotidectomy in these cases, after the superfacial part of the parotid

has been removed as in a standard conservative parotidectomy and the facial nerve has been freed and lifted up, is to enlarge the constricting orifice of the stylomandibular tunnel by division of the stylomandibular ligament and fracture of the styloid process at its base.

SUMMARY

1. Four cases of parotid tumour with retro-pharyngeal extension are described, 3 being mixed tumours and 1 a neurinoma.

2. The surgical anatomy, clinical features, pathology, and technique of treatment are described.

Acknowledgements.—As already stated, we have been able to collect for study such a relatively large number of these rare cases owing to the kindness of colleagues in referring them to us. We are grateful to Mr. O. D. Morris, of the Ashford Hospital, Ashford, Middlesex, for *Case* 2; to Mr. Anthony Till, of Oxford, for *Case* 3; and to Dr. J. S. Fulton, of the Liverpool Radium Institute, for *Case* 4. We are also grateful to Dr. Fulton for the photographs of his patient. To our colleague Mr. J. P. Monkhouse we are grateful not only for introducing us to the problem but also for his co-operation in performing the pharyngeal part of the operation in *Case* 1, which was under his care, and for standing by in *Case* 2, when we were working out the external approach and were uncertain whether a pharyngeal operation would be necessary in addition.

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COMPLICATIONS ASSOCIATED WITH THE USE OF A LONG AFFERENT LOOP IN THE POLYA TYPE OF PARTIAL GASTRECTOMY

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PARTIAL gastrectomy is one of the most satisfactory major operations of to-day, and in the past ten years physicians have been referring to their surgical colleagues an increasing number of peptic ulcer cases for surgical treatment. Indeed, in the group of hospitals in which I work 66 per cent of those admitted with ulcer are treated by operation.

FIG. 435.—Long afferent loop having herniated from right to left through the retro-anastomatic gap causing obstruction.

Surgical treatment is popular because the mortality is now down to around 3 per cent, and because about 85–90 per cent of cases are either cured or greatly better than before operation. This leaves about 7 per cent who continue to suffer dyspepsias of different patterns, and it is on this group that attention has been focused in the past few years. These studies have led to a more skilful selection of cases for operation, as also to points in technique that promise to reduce the incidence of post-gastrectomy symptoms, and the cumulative experience of the large surgical centres of the world has begun to make it possible to analyse the cause of the trouble in some of these patients and to put it right.

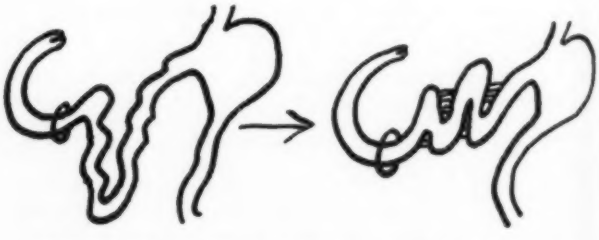

FIG. 436.—Long afferent loop to lesser curve having become concertina'd and giving the afferent-loop syndrome.

Amongst our experience of over 1000 cases of peptic ulcer treated by one or other form of partial gastrectomy are a number of post-gastrectomy complications from other hospitals sent to us for investigation of their post-gastrectomy problems. The use of the long afferent loop in the Polya operation has been found to be associated with a sufficient number of serious complications to issue a warning against its employment and this short communication deals only with the small group associated with a long loop.

1. Within the past four years various authors have published cases of high intestinal obstruction

developing within 4–8 days of an antecolic Polya-type partial gastrectomy. There are six or seven different patterns of this obstruction, one of them being a long afferent loop passing from right to left through the gap between the anastomosis in front and the transverse colon behind (*Fig.* 435). It is the most dangerous of these post-gastrectomy obstructions, since, on the one hand, it forms a closed loop, and, on the other, the blood-supply is soon embarrassed, so that the loop becomes gangrenous. Two of West's (1953) cases were diagnosed at autopsy only, and death resulted in a number of other published cases. As pointed out in my various papers (Stammers, 1952, 1954, 1956) on these post-gastrectomy obstructions, the gap between the anastomosis and transverse colon must be closed at the first operation in order to eliminate the risk of these admittedly uncommon herniations. An interesting point with some of the other types of herniation is that although usually occurring within the first few days of operation, they may develop months or even years later. There is also evidence that the herniation may be intermittent and the obstruction partial only—indeed, sometimes not much more than mechanical embarrassment—and it is tempting to suggest that such events might account for the vague, bizarre, and occasional attacks of pain and vomiting that sometimes affect patients after gastrectomy. It is conceivable that the long-afferent-loop type could

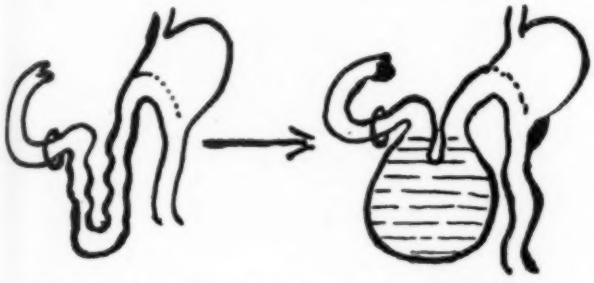

FIG. 437.—Long afferent loop to lesser curve having become dilated and acting as a trap for bile and pancreatic secretions.

behave in a similar recurrent manner, but my own cases and all those I have seen reported, or discovered in conversation with colleagues, have been acute in onset and urgent in their demand for treatment.

2. The mechanism of the afferent-loop syndrome suggested by Norman Lake in 1948 and described so clearly by Steinberg in 1949, and by Wells and Welbourn in 1951, is now generally accepted as one definite cause of this particular pattern of discomfort. On 5 occasions now I have encountered a variation of this mechanism, all from other hospitals, and in each case a long afferent loop (25–40 cm.) had been employed (*Fig.* 436). Over the course of years this loop had become concertina'd, producing the typical early post-prandial fullness and distress, relieved by a vomit of almost pure bile. In each case the loop had to be unravelled and excised, since it was too long for entero-enterostomy. The operation resulted in the optimum length of 10–15 cm. and the patients were all relieved of their symptoms.

3. The third complication resulting from the use of a long afferent loop produced even more subtle symptoms, and these after several years of greatly improved health. The sketches (*Figs.* 437, 438) explain what happened in the two cases concerned; one was an afferent-loop to lesser-curve anastomosis, brought to my notice by my colleague Dr. C. Hawkins, and the other was afferent to

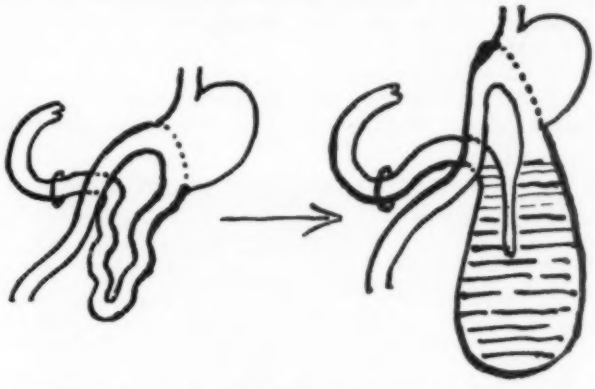

FIG. 438.—Long afferent loop to greater curve becoming dilated and acting as a sump containing bile and pancreatic secretions.

greater-curve anastomosis and was one of my own patients. It will be seen that in each instance the long loop slowly stretched and distended until it became a veritable sump in which collected bile and pancreatic secretions resulting from the various stimuli of food, with the result that the secretions never became mixed with the stomach contents. The result in each case was loss of weight and energy with an annoying diarrhœa due to steatorrhœa. Unlike the afferent-loop syndrome, including those few cases resulting from a concertina'd afferent loop, there was minimal post-cibal distress because the loop had become so commodious. It is probable that minor degrees of this sumping mechanism occur which result in less severe disturbance, yet a setback in the good health at first restored by the partial gastrectomy. Indeed, interference of fat absorption may be shown in a number of gastrectomy patients who fail to reach normal weight for age and height. The removal of the large distended loop and reconstitution into one of some 10–15 cm. restored these two patients to normal health.

From these few cases, I think there is a strong argument against using an afferent loop of more than 15 cm. in length. At the same time, in that a number of authorities do use the long loop, it is worth remembering that patients not maintaining their original improvement may have undergone one of the mechanical changes described in these few cases.

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SURGERY OF FUNNEL CHEST AND CONGENITAL STERNAL PROMINENCE*

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JOHN HUNTER, writing of the fourth series in his museum, which contains preparation of muscle-fibres, states muscle to be " one of the simplest forms of an active solid ".

Such a description is apt when applied to the muscle of the diaphragm, which by a constant but aberrated action is responsible for the two chest-wall deformities to be discussed.

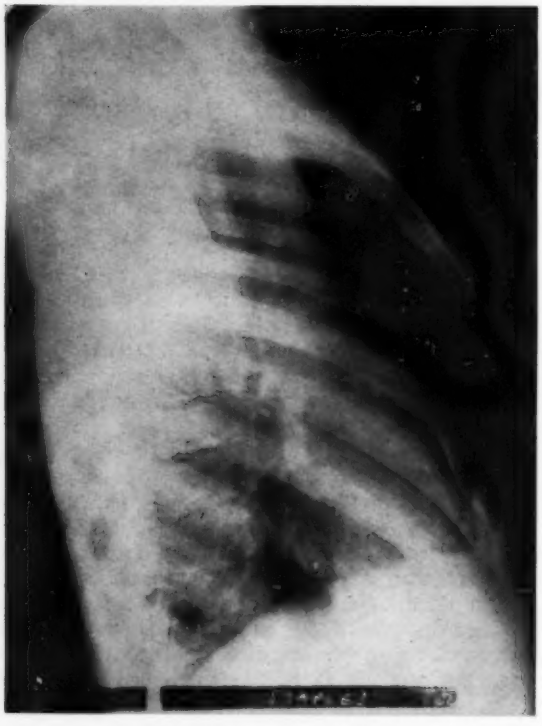


FIG. 439.—Typical X-ray change in a case of congenital sternal prominence. There is a marked increase in the A.P. diameter of the chest at the level of the xiphisternal junction.

Both these conditions—funnel chest (pectus excavatum) and congenital sternal prominence—which become manifest by changes in the bony and cartilaginous thorax, are initiated and maintained by the abnormal action of the diaphragm. In both deformities the first sign that something is amiss is noted in the sternum itself. Changes in the costal cartilage then occur, as these have no option but to follow the sternum to its displaced site. A clear definition of both deformities is important.

' Congenital sternal prominence ' seems the most apt name to describe the condition shown in *Fig.* 439. This is often loosely termed ' pigeon chest ', and of course this is wrong. Such a condition is shown in *Fig.* 440 and will not be discussed in this paper, and correctly should be named ' manubrio-sternal prominence '.

In congenital sternal prominence there is a marked forward tilt of the sternum and this continues on in the same line as the manubrium; thus the A.P. diameter of the thorax around the level of the xiphoid is greatly increased. There are always present lateral sulci, most prominent in the right and left sixth interspace (*Fig.* 441). These become accentuated on deep inspiration. If there is any movement of the lower sternum or the xiphoid on inspiration it will be forward and never backward.

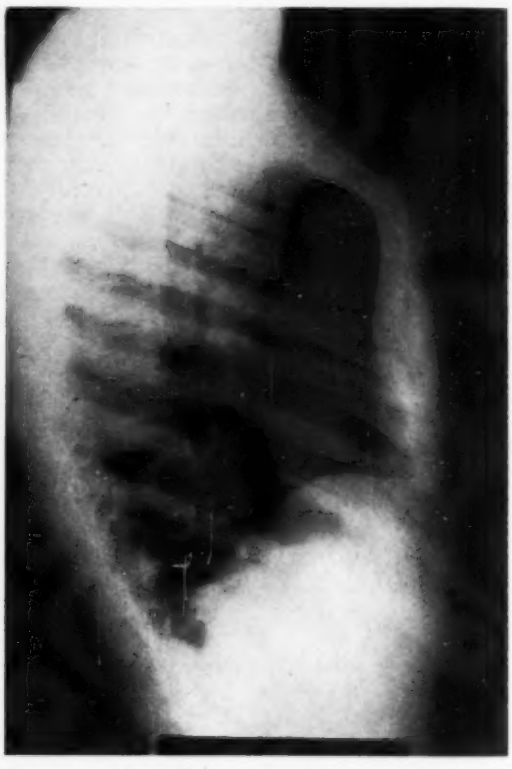


FIG. 440.—' Pigeon chest ' or manubriosternal prominence.

In established funnel chest there is backward displacement and movement of the sternum, if it is not fixed, and angulation of the costal cartilages in the anterior posterior plane. The A.P. diameter at the level of the xiphoid is decreased, particularly on inspiration. Movement of the xiphisternal junction on inspiration is always backwards. The result is a hollowing of the anterior part of the chest, maximal over the lower sternum (*Fig.* 442).

Rickets has been quoted as the cause of these deformities, but a study of even a small series of cases will show this view to be untenable on clinical examination and on radiological and biochemical

* Hunterian Lecture given at the Royal College of Surgeons of England on May 17, 1956.

studies, and investigation into the social background of the patient will usually fail to support such an aetiology.

Most present writers on the subject agree in indicting the diaphragm as the active productive force (Brown, 1939; Ravitch, 1949; Brodkin, 1953; Hirtze, 1954; Lester, 1954; Hausmann, 1955).

FUNNEL CHEST (PECTUS EXCAVATUM)

AETIOLOGY

The fibromuscular diaphragm basically consists of a large sheet of peripheral muscle concentrically inserting and acting on the central tendon; the contraction of the muscular ring causes descent of the central tendon.

The forces are balanced and the action of the muscle does not normally produce retraction of the sternum or cartilaginous thorax.

Counter-traction to this muscular pull anteriorly is produced by the so-called bucket-handle action of the ribs and costal cartilages. This counteraction is particularly important anteriorly along the 6th and 7th costal cartilages because the weaker and shorter muscle component of the diaphragm needs support in this region from the more powerful lateral and posterior fibres; also the anterior costophrenic sinus is not developed in young children; thus the pull is more direct and this anterior counteraction is even more necessary in the young.

This balance is upset in the funnel chest. There is a disparity of the forces and the xiphisternal region is dragged in on inspiration, to be released again on expiration. The paradoxical movement of the lower sternum is synchronous with inspiration. The evidence in favour of the diaphragm being the motive productive force is as follows:—

1. In the early stages, before a fixed deformity occurs, a typical funnel chest is produced only on inspiration. The degree depends upon the amount of inspiratory effort. Once diaphragmatic relaxation occurs, obliteration of the deformity results. Even in established deformities, before final fixity occurs, paradox of the lower sternum is seen on inspiration. Screening the patient in the lateral position confirms the clinical deduction that with descent of the diaphragm, backward retraction of the lower xiphisternum occurs.

2. Unilateral paralysis of the phrenic nerve in the neck by local anæsthesia produces a marked alteration in the paradoxical pattern of the lower sternum. There is still paradox, but it is asymmetrical. There is a latent period before the paralysed side moves, and this is best seen by observing the anterior end of the 6th and 7th costal cartilages. These are being dragged in by the fibres of the opposite side. Bilateral paralysis of the nerves in a labile deformity causes cessation of the deformity in any stage of respiration. The validity of these findings was checked by screening the patient to confirm that the diaphragm was paralysed.

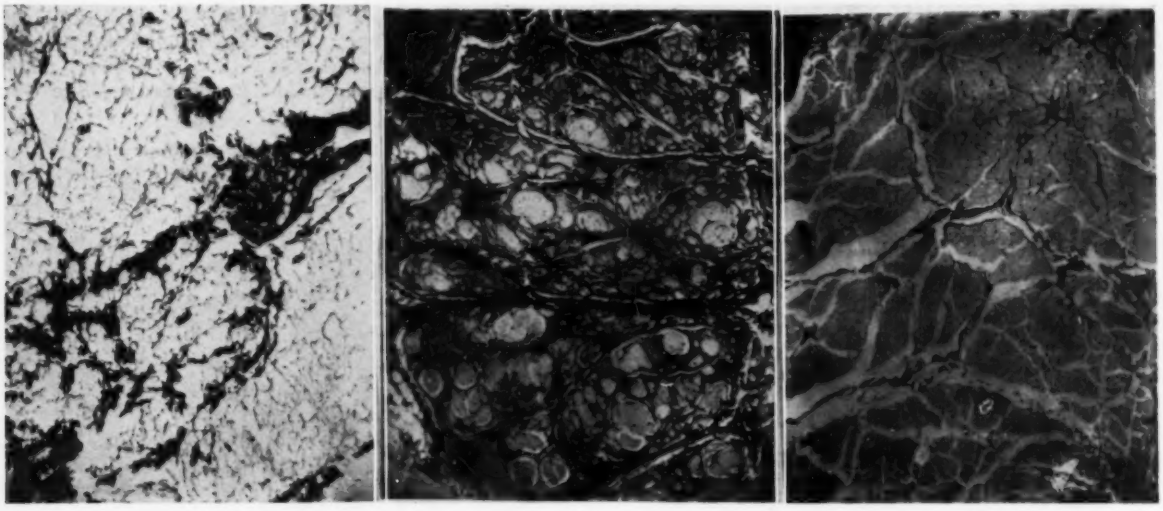
FIG. 441.—A typical case of congenital sternal prominence, showing the well-marked lateral sulci, which deepen on inspiration.

FIG. 442.—A case of pectus excavatum.

3. It has been observed frequently that 'dissociated paradox' occurs when the xiphoid and anterior diaphragm attachments are released as a result of repair in these cases. Having dissociated the anterior diaphragmatic attachments from the lower sternum and costal cartilages, lower sternal retraction on inspiration no longer occurs, but retraction of the xiphoid does occur. With a finger on the lower sternum and one on the detached xiphoid it will be seen that paradox of the xiphoid only occurs.

To explain the exact nature of the congenital defect in the diaphragm is more difficult. There is

no record of the autopsy findings in such cases. Brown (1939) stated that it could be due to a short central tendon. This theory is probably incorrect, because it is unlikely that complete obliteration of the deformity could occur on expiration; also in many severe cases in my series, whilst carrying out a repair, the anterior aspect of the diaphragm has been closely observed, and macroscopically it has differed in no way from the normal controls. In all cases muscle-fibres were present arising from the xiphoid and 6th and 7th costal cartilages.



A B C

FIG. 443.—A, Biopsy from a severe case of funnel chest, showing complete absence of muscle-fibres. B, Biopsy from a funnel chest, showing that the anterior diaphragm is not completely replaced by fibrous tissue, but that there is muscle intermingled with fibrous tissue. C, Biopsy from a normal control, showing well-developed muscle tissue without any fibrous tissue breaking up the muscle.

This theory of a short central tendon has been held for many years, and is reported in the earlier writings. Woillez, a French physician of over a hundred years ago, stated that ' dépression sternaire ' was due to a shortening of the tendinous centre of the diaphragm.

A hypertrophied substernal ligament has been commented on many times as being the likely cause. The only way this could act would be by a strong well-developed ligament continuing down into the central tendon. There is no evidence to support this. In 54 operated cases I have noticed nothing remarkable about this ligament except that there is little to remark, and it has never continued across to the anterior muscle of the diaphragm.

Brodkin (1953) felt that the muscular component of the diaphragm derived from the septum transversum was deficient in muscle-fibres, and because of this weakness it was pulled in by the more powerful surrounding muscle, and thus had no option but to descend with the central tendon, dragging the lower sternum with it. Brodkin's deductions are original and thoughtful, and Hirtze (1954) strongly supports Brodkin's work. In an effort to confirm this theory I commenced taking muscle biopsies from the anterior portion of the diaphragm, and also taking biopsies from controls. The age groups were comparable.

It soon became evident that in the case of funnel chest the anterior portion of the diaphragm, while macroscopically appearing normal, was extremely thin and even a small biopsy would result in the peritoneum being exposed.

The histology of these biopsies has done a great deal to confirm Brodkin's work. It is seen that in the cases of funnel chest the anterior portion of the diaphragm is deficient in muscle and has a great deal of fibrous tissue mingling with islets of muscle. *Fig.* 443 shows a biopsy from a severe case of funnel chest compared with a less severe case and a normal control. It is seen in one that the muscle-bundles are intermingled with masses of fibrous tissue and this substance almost predominates. In the control there is well-developed normal muscle.

It would appear from these microscopy findings that Brodkin's deductions must be accepted. Such findings correlate well with the clinical behaviour; they will explain why paradoxical movement is extreme in some and the final deformity severe, while in others it is limited in range and early arrest of the deformity occurs. These various gradations must be directly related to the proportions of muscle and fibrous tissue in the anterior component of the diaphragm. If heavily laden with fibrous tissue then the anterior component cannot compete as when only slightly laden, and as a result is more readily overcome by the surrounding muscle, and has no choice but to be dragged down with the central tendon.

It would appear that such partial replacement by fibrous tissue may occur unilaterally, and thus give rise to a unilateral deformity. Such cases do occur clinically and these cases are seen often enough. Such an occurrence can be explained by Brodkin's deduction, but could never be explained on the theory of a short central tendon.

Clinically, progression of the deformity can be noted from three months onwards, and secondary changes in the sternal body and costal cartilages can occur. Once these are present in expiration they are irreversible.

The sternum becomes angulated usually at the level of the second and third costal cartilage. The ribs become very oblique and the costal cartilages angulated backwards.

What was once a labile deformity, appearing on inspiration and disappearing on expiration, becomes apparent at all phases of respiration. In the majority of cases there is still sternal paradox on inspiration, of varying degrees, and this may persist through to adult life. In a minority of cases the sternum is fixed completely in its displaced position and even forced respiration produces no movement. In such cases the deformity has reached its attainable maximum, and such a state can be arrived at early in life (*Fig.* 444).

Hence a severe degree of funnel chest presents a patient with marked decrease in the A.P. diameter of the lower thorax, marked obliquity of the ribs,

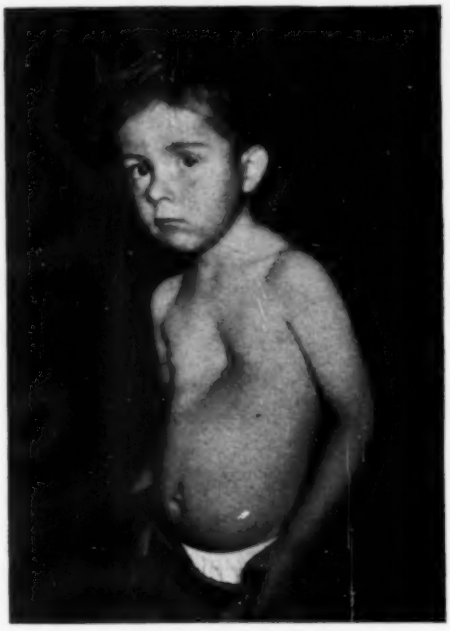


FIG. 444.— Child, aged 4 years, which has a completely fixed deformity, and in such a case there is no movement of the sternum at all on deep inspiration. The deformity has reached its attainable maximum.

angulation of the costal cartilages, and in most cases a shift of the heart to the left. Further changes may deform the patient and accentuate this deformity, the abdomen becoming markedly protuberant, and severe kyphosis occurring (*Fig.* 444).

SYMPTOMATOLOGY

To state that all patients with an excavatum deformity have symptoms would not be true. It depends on the degree of the deformity; in many it is too trivial. Examination of the case will determine its degree, and measurements are valueless. Each case must be considered as a structural whole. For example, a mild degree of displacement in a case of platythorax can produce severe symptoms (*Fig.* 445). Of those cases referred to surgical outpatients many have symptoms, but it is reasonable to assume that such a high percentage of cases would not be found in a similar series picked at random.

These patients can be put into three main groups:

Group 1: Disabled to such a degree that they actively seek medical aid. In my series of 54 surgical

FIG. 445.—A case of platythorax who also had an excavatum deformity and paradox on inspiration. Cases with platythorax and associated excavatum deformity may get symptoms even though the actual range of paradoxical movement is not great.

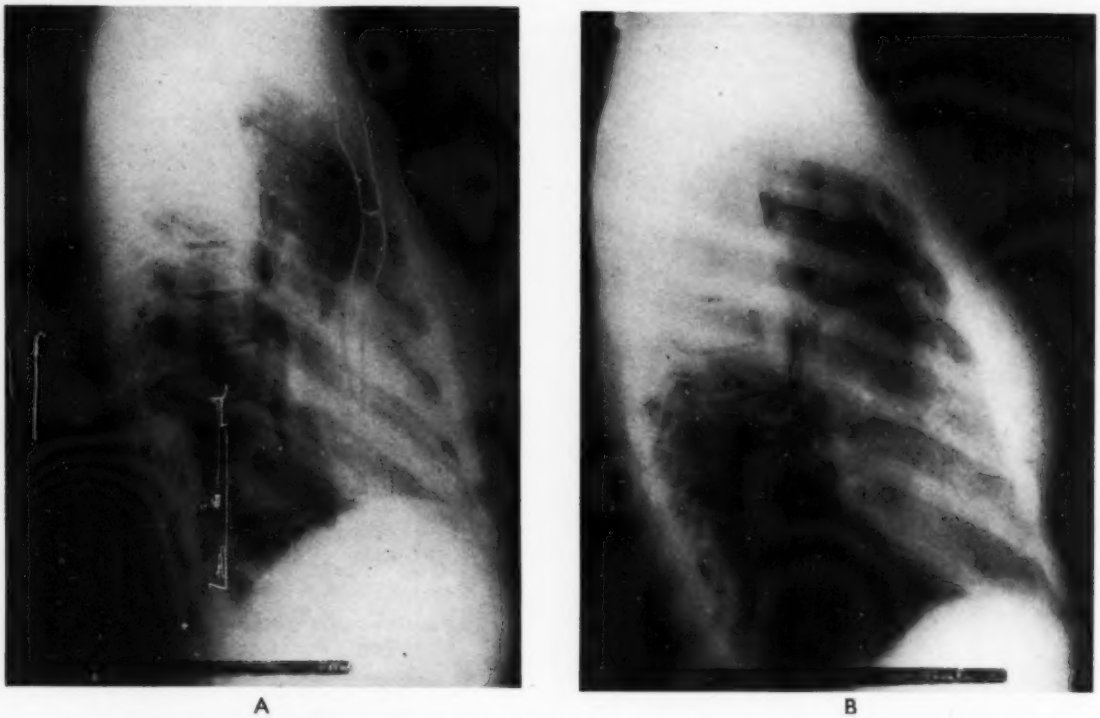
FIG. 446.—Man with severe degree of excavatum deformity, who was disabled by dyspnœa and precordial pain on exercise.

cases there were 14 such. Their symptoms were severe enough to render them incapable of pursuing the activities of their age, and in some cases rendering

them unable to perform their work. The age range in this group was from 2 years to 37 years. They were troubled by two or more of the following symptoms: Dyspnœa to a distressing degree on moderate exertion; precordial pain; palpitations; and syncope on moderate exertion. Two suffered from persistent dysphagia. The child of 2 did not have these symptoms, but suffered from such severe

To deny that this deformity can carry disability only means that such cases have not been seen. It does not mean that they do not exist.

Two years ago I operated on a female 37 years of age. She had suffered from progressive dyspnœa for four years; associated with this, there was precordial pain and palpitations. She had of necessity given up her work as a bus conductress and she



A B

FIG. 447.—A, Lateral radiograph of patient who, besides suffering from dyspnœa and palpitations on exercise, also had persistent dysphagia. B, The same case one year post-operatively. She has now been relieved of her symptoms.

and repeated lung infections that both his parents and the doctor were anxious lest he should not survive another winter. The degree of deformity in these cases was marked (*Fig.* 446).

Dysphagia has been recorded previously by Alexander in 1931. In both these cases it occurred frequently and always with solid or dry foods. Barium studies showed depression on the left side of the lower third of the œsophagus due to pressure by the displaced heart. But there was no hold-up to thick or thin barium. This can be seen from *Fig.* 447 A, when mediastinal compression of such a degree was present to explain this difficulty. Both cases with dysphagia were unable to walk up hills because of dyspnœa and precordial pain.

So often these people have been denied symptoms by their physicians and labelled neurotic. Having elevated the sternum, which has been resting directly on the pericardium, on several occasions, I have no doubt that these symptoms are real. The crippling effects which a funnel chest can produce have been presented in the writings of many authors (Sauerbruch, 1931; Carr, 1932; Alexander, 1931; Oschner and de Bakey, 1939; Nissen, 1944; Lester, 1946, 1950; Master and Stone, 1949; Dorner, Keil, and Schissel, 1950; Ravitch, 1949; Chin and Adler, 1954).

could no longer ride a bicycle. Walking up hills was avoided at all costs owing to the pain and dyspnœa which it produced. She had a severe degree of compression deformity, and the internal measurement from the xiphisternum to the vertebral bodies was only 2 in. Marked lævocardia was present. She is now free of all symptoms and is back working a full day. There are many similar cases in the literature. *Fig.* 447 shows the pre- and post-operative films.

Group 2: The second group have symptoms of a degree to be a conspicuously worrying feature of their life. The two main symptoms are recurrent chest infections and dyspnœa. Their dyspnœa is not severe enough to exclude them from games or full activities, but they fail to keep up with their fellows and often show a disinclination to play because of this. The story of recurring 'bronchitis' is a common one and can be of such a degree and frequency as to alarm the doctor and the parents. The fact that this is commonly associated with this deformity has been quoted often enough, and can be found in the writings of the authors in the bibliography. Brown (1951) has stated that frequent colds are most satisfactorily cured by surgery.

Twenty-three of my cases have such a story, and in all of them paradox was marked. The

history of repeated colds becomes important when the parents state their concern over this feature. Their story has been borne out whilst in-patients. Indeed, in some, bilateral bronchograms have been performed with a conviction that the patient has associated bronchiectasis. It has been observed by the physiotherapists and the nursing and medical staff that these children appear ' wet ', and yet seem unable to produce sputum. After surgery the transition from this state is quite rapid, and they can lift their secretions and rapidly become ' dry '. Green sputum has been recovered repeatedly at bronchoscopy following termination of the repair.

Auscultation in these patients reveals persisting basal crepitations. Such cases always have marked paradoxical movement of the sternum, and this must result in sputum retention and even sputum impaction.

All these children are screened, and the diaphragm has a full and active range of movement, particularly behind. It pivots on its anterior attachment and this movement must produce a high negative intrathoracic pressure, particularly over the basal segments, and the retained secretions resulting from the anterior paradox are further borne in to the segmental bronchi (*Fig.* 448).

Group 3 : The third group have no symptoms, and even on direct questioning no positive history is forthcoming. Yet of this group 50 per cent have given a history of marked improvement after operation. This information has always been given voluntarily by the parent and is always the same, that the child is much more active and less easily fatigued. It is similar to the parents' story after the ligation of a patent ductus arteriosus in an asymptomatic child.

Types of Deformity.—In this series of 54 cases, all have fallen into three main types, and there is remarkably little overlap in the types :—

Type I : This is a localized deformity, well illustrated in *Fig.* 449. There is symmetry of the two sides ; the angulation of the costal cartilages is acute and occurs well inside the nipple line. This acute angulation usually occurs at the fourth costal cartilage, and continues down to the seventh. The resultant hollowing is localized and is the type you may ' put your fist in '. Rolling out of the costal margin is unusual.

Type II is more diffuse. Angulation of the costal cartilage occurs farther out and there is a gentle slope in to the sternum. The second costal cartilage is involved frequently with the third, and continues through to the seventh. A marked rolling out of the costal margin is often present. The deformity resembles an inverted plateau, with gently sloping edges. (*Fig.* 450.)

Type III : This is basically a unilateral deformity and is asymmetrical. The sternum is tilted and the tilt is always to the left, and while sternal depression is present it is more marked on the left. The backward angulation of the ribs occurs on the left, and the acuteness resembles Type I. Whereas the angulation on the right is even closer to the sternum, and because of the tilt forward of this margin, the costal cartilages run well forward before they dip and produce a carinated ridge down the right side. There is usually a deep groove along the left sixth interspace, which is well seen on inspiration (*Fig.* 451).

Paradox, protuberant abdomen, and kyphosis may be present in any group, but severe kyphosis is more often present and is more persistent after surgical correction in Type II. In this series, 37 were of Type I, 11 of Type II, and 6 of Type III. It has

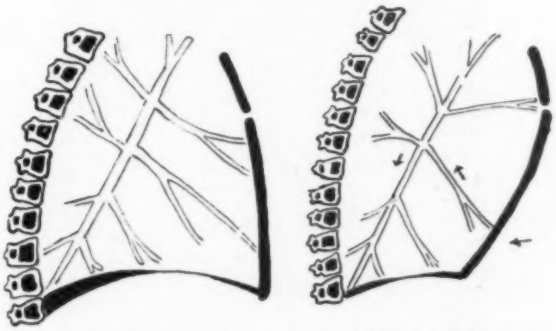


FIG. 448.—Diagrammatic representation of the chest-wall movement on inspiration. If this range of paradoxical movement is great, it can cause sputum retention and consequent infection.

not been apparent that any one type produces symptoms of its type. In the disabled group, 8 were Type I, 4 were Type II, and 2 were Type III. It was felt, however, that careful attention to type is important because this is one of the features that influences the selection of cases for surgery, and a different cosmetic prognosis is given for the different types. This will be discussed later.

Dyspnœa and Respiratory Infections.—Basically there are two symptoms to explain : Dyspnœa, and respiratory infection. Precordial pain, palpitations, and syncope are associated with dyspnœa, and in cases where dyspnœa predominates, one or all of the above features will usually be present.

Repeated chest infection appears predominantly in the younger age groups, and dyspnœa, with attendant cardiac symptoms, occurs later. An analysis of the 54 cases, selecting those with symptoms and correlating these with their age, is shown below. The reason for chest infection has been

Average age of group with respiratory infections	4·6 years
Average age of group with dyspnœa and cardiac symptoms	20·5 years

explained previously, and it is easy to understand that this symptom would occur in the younger age groups, where paradox is more marked and the chest wall more mobile. As fixity occurs, respiratory infection tends to disappear, and I have never seen a patient with a fixed deformity who complained of repeated chest infections. But many adults with fixed deformities stated that in their earlier years they were prone to repeated respiratory infections.

Efforts have been made to explain dyspnœa in the older age group. Lung function studies have thrown a little light on this, and the findings are much in agreement with those of Brown (1951). A series of 14 cases was investigated before and after operation, and the period of investigation postoperatively was at least six months. The findings may be summarized as follows :—

1. *Maximum Breathing Capacity.*—In 4 cases the pre-operative M.B.C. was considerably less than the predicted value. In the remaining cases the pre-operative M.B.C. was within the normal range. In 5 cases there were rises of more than 10 per cent in the M.B.C. after operation, which is a significant rise in value. The mean change in M.B.C. post-operatively was 10 per cent. This is just significant.

2. *Vital Capacity.*—Six cases had a vital capacity below the normal range before operation. The change in vital capacity after operation was generally very small. The mean change was a rise of 2 per cent. This is not significant.

3. *Timed Vital Capacity.*—With the possible exception of one case, all cases showed normal value for the air exhaled in the first second of the timed vital capacity test, when this was expressed as a percentage of the total vital capacity. There was no evidence of obstructive ventilatory defect in these cases. After operation there was a tendency for the volume of air exhaled in the first second of the T.V.C. test to rise. The mean value equalled 5 per

FIG. 449.—Type I deformity.

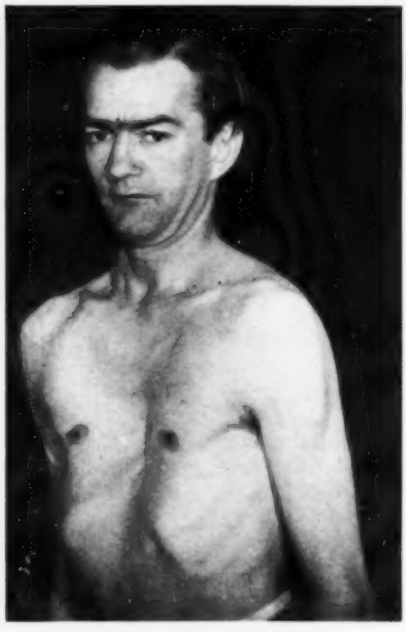


FIG. 450.—Type II deformity.

FIG. 451.—Type III deformity.

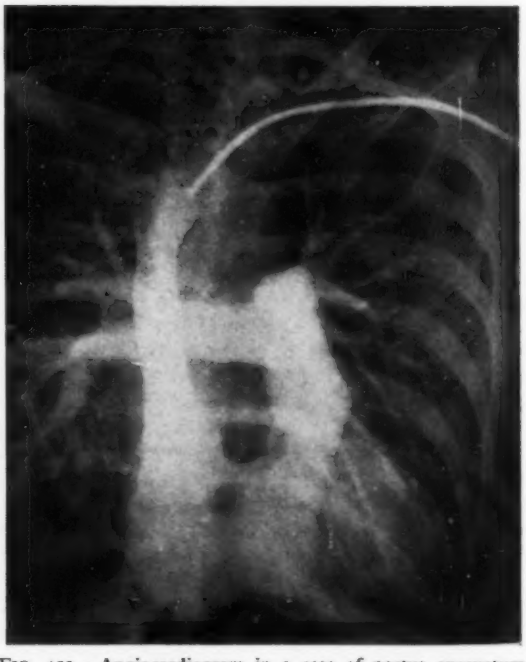


FIG. 452.—Angiocardiogram in a case of pectus excavatum, showing the shift of the heart to the left.

cent. But this is of doubtful significance. All patients on whom these tests were performed had deformities which were practically fixed, and none of them had symptoms of respiratory tract infection or of dyspnœa. I am convinced that the symptoms of dyspnœa, precordial pain, palpitations, and syncope are due to impaired cardiac action. The reasons for this deduction are as follows :—

a. The nature of the deformity, where the lower A.P. diameter of the chest is reduced and there is marked displacement of the heart to the left. This is squeezed from its normal position by the displaced sternum, and usually it is squeezed to its limit within the fixed pericardial sac. The displacement is readily confirmed by radiography and further confirmed by palpation along the left sternal border, where right ventricular pulsation is as readily felt as in the case of mitral stenosis. While all this can be deduced clinically and radiologically, it is more readily seen when the anatomy of the deformity is studied at operation. Direct pressure on the pericardium has been observed in 8 cases at operation. An angiocardiogram showing such displacement is seen in *Fig*. 452.

b. It is reasonable to assume that there is also a rotation of the heart. Stadtmüller (1920), in 8 autopsy cases, observed rotation about the sagittal axis.

c. Adults in this series have never complained of respiratory infections. This is due to the deformity having reached its maximum, and paradox is no longer a factor. The sternum is fixed or nearly fixed, and the respiratory aspect has gone, but cardiac squeeze and impaired function become manifest.

If cardiac dysfunction is present it should be recordable. The resting cardiac output is of no value, and the cardiac output should be recorded after exercise both pre- and post-operatively. To date I have not had the facilities to pursue this. Ravitch (1951) and Lindskog and Felton (1955) have recorded cardiac output in a few cases only, and two of these authors have noted a marked rise in pulmonary artery pressure on exercise.

Electrocardiography.—Electrocardiograms (E.C.Gs.), including unipolar limb and chest loads, were taken on 17 patients before operation and on 10 after operation. Five features were commonly met with (*Fig*. 453): (i) An rSr′ complex in the right chest leads VI–2 (88 per cent); (ii) Inverted T in lead III (88 per cent); (iii) Prominent S in V6 (82 per cent); (iv) An electrically vertical heart (77 per cent); and (v) Right axis deviation (59 per cent). Abnormal P waves, peaked or bifid, were found in 29 per cent of the tracings. Right bundle-branch block, complete or incomplete (QRS duration 0·12 sec. or 0·10 sec. respectively), was recorded in 3 cases (18 per cent) and a prolonged PR interval (exceeding 0·20 sec.) in 1 case.

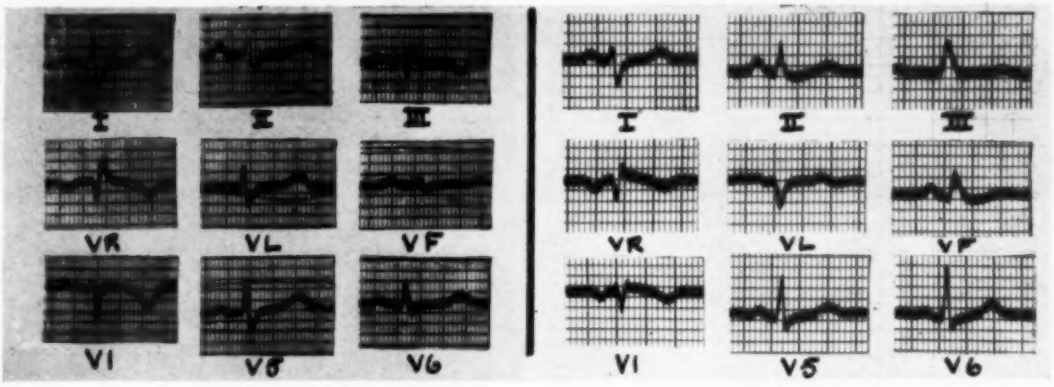


FIG. 453.—Electrocardiograms in two cases of pectus excavatum. Both electrocardiograms show the typical features, an rSr′ complex in VI, inverted or flat T in III, and S wave in V6. In B there is right axis deviation and an electrically vertical heart.

An rSr′ complex* is seen in 5–20 per cent of normal E.C.Gs., the higher incidence being in children. The two positive waves are usually small, seldom exceeding 0·7 millivolt in amplitude and 0·04 sec. in duration. Such a complex may be invariably recorded in direct leads from the region of the infundibulum of the normal right ventricle, the r′ wave resulting from the normal late activation of the crista-supraventriculars. It may appear in leads VI–2 when the apex is tilted backwards causing the right ventricular infundibulum to face the level of the standard chest leads, VI–2 (Lepeschkin, 1951). The high incidence of rSr′ complexes in VI–2 in the present series is doubtless the result of displacement of the heart backwards and to the left by the depressed lower sternum, a fact which would also account for the related findings of right axis deviation in the standard limb leads, S wave in VI–6, and an electrically vertical heart. E.C.Gs. have been taken after operation in 10 patients, all of whom showed an rSr′ complex pre-operatively; in 2 of them the rSr′ complex had been replaced by rS complexes, suggesting that the heart had been restored to a normal position. It is possible that a similar change may be found in others at a longer interval after operation. The E.C.G. in this condition has been studied by a number of authors, but no mention has been made of this common finding even by those who included multiple chest leads (Evans, 1946; Dorner, Keil, and Schissel, 1950).

Inversion of T in lead III with an upright T in lead II (present in 88 per cent of this series) is a

* An rSr′ complex is composed of a small R wave (conventionally written with a small 'r'), and normal S wave, and a second small positive wave, written as 'r prime' or 'r.'.

frequent finding in normal hearts, especially when the diaphragm is high from any cause. Lowering the diaphragm by a deep breath, thereby altering the position of the heart, corrects the inverted T in lead III. The effect of deep inspiration has not been observed in this series, but it seems probable that a common cause exists for the rSr′ complex in VI–2 and the inverted T in III, namely displacement of

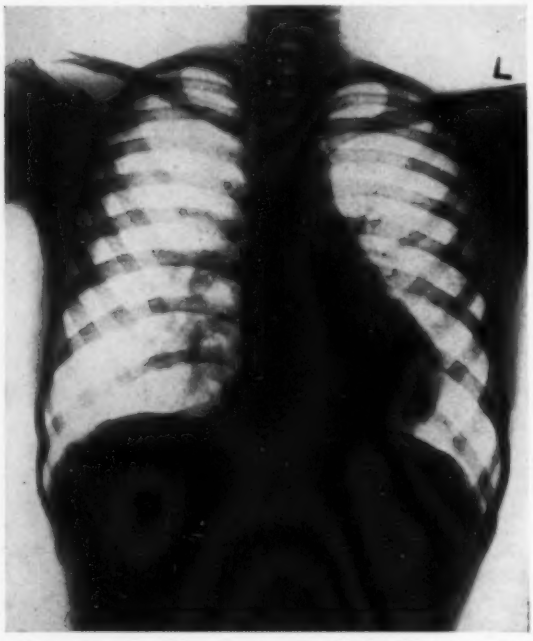


FIG. 454.—P.A. view showing the shift of the heart to the left and the crowding of the anterior ends of the 4th, 5th, and 6th ribs.

the heart by the depressed sternum. Similar T inversion has been noted by others (Carr, 1932; Grieshaber, 1937; Nissen, 1944; Sweet, 1944; and Brodkin, 1953).

Abnormal P waves, widened or notched, occurred in 29 per cent of the present series. The explanation

Table I.—MEASUREMENTS FROM XIPHISTERNAL JUNCTION TO ANTERIOR ASPECT OF THE VERTEBRAL BODIES

AGE	PRE-OPERATIVE MEASUREMENT	POST-OPERATIVE MEASUREMENT	NUMBER OF CASES
0–10	2·1	3·2	16
10–15	2·75	3·75	2
15–20	2·5	3·6	3
25–30	1·75	3·5	4

of this finding is as yet unknown, but it too is probably a factor of cardiac displacement, although right auricular deformity or indentation by the depressed sternum is a possibility. Dorner and others (1950) describe a 'dilated right auricle' shown by angiocardiography, but the possibility of flattening of this chamber by the depressed sternum is not mentioned. Other workers have noted abnormal P waves in the standard limb leads but did not explain them (Grieshaber, 1937; Nissen, 1944; Sweet, 1944; Teplick and Drake, 1946; and Master and Stone, 1949).

Emphasis has been laid on the fact that the E.C.G. features in pectus excavatum are largely the result of cardiac displacement rather than intrinsic heart disease. However, in certain cases organic cardiac disease cannot be discounted and is suggested by the appearance of right bundle-branch

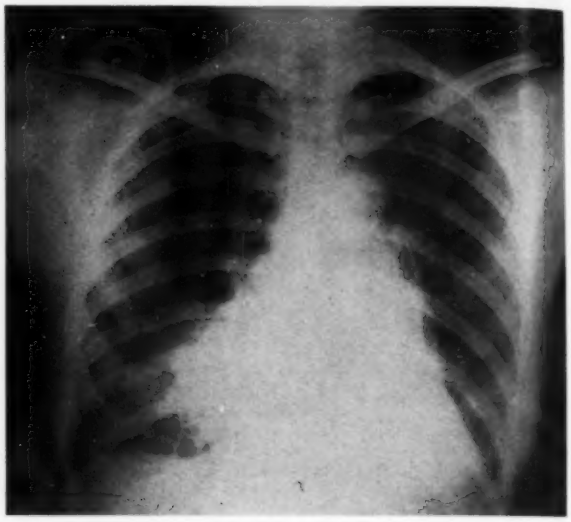


FIG. 455.—An extreme case of pectus excavatum, Type I, which had been treated for pulmonary disease which did not exist. Such X-ray changes as these are not uncommon in adults with a severe degree of deformity.

block (3 cases in the present series) and one instance of prolonged PR interval, a finding also noted by Edeiken and Wolferth (1932). Dorner and his colleagues (1950), indeed, have confirmed that some degree of right ventricular systolic hypertension (55/2 mm. Hg) in one case was reduced to normal (27/2 mm. Hg) after surgical correction of the pectus with increase in the cardiac index (cardiac output per square metre body surface area) from 1·4 to 2·9 l. per square metre per minute. In their hands other cases gave normal catheter findings.

The electrocardiographic studies in 17 patients with pectus excavatum showed a fairly consistent pattern comprising a rSr′ complex in VI–2, T inversion in lead III, S wave in VI–6, right axis deviation, and an electrically vertical heart. These changes are the result of cardiac displacement by the depressed sternum rather than by intrinsic heart disease, although the latter may possibly be an uncommon sequel. Right bundle-branch block and a prolonged PR interval were occasional findings. In 2 of 10 patients taken after surgical correction of the pectus, the rSr′ pattern had disappeared.

X-ray Changes.—These are characteristic. While a lateral film should be taken, it is possible to diagnose the condition on a P.A. film alone (*Fig.* 454). Also, with experience, it is possible to tell the severity of the deformity on such a film. In 64 cases reviewed radiologically, the heart was in a normal position in 3, and in the remainder there was marked cardiac displacement to the left. Hence it is seen that displacement to the left is usual, and this is to be expected, as it is the natural route for

the heart to take within the pericardial sac, if it is squeezed from its normal position. These findings are not entirely in agreement with Brown (1951), who found a shift to the right in 3 cases, the heart being central in 17, and a shift to the left in 24. This shift occurs very early in life and can be seen in babies.

The ribs have a marked obliquity and there is often crowding of the 4th, 5th, 6th, and 7th ribs anteriorly. The vascular markings on the right at the hilum become very prominent, and indeed have been confused by some unwary physicians as representing pulmonary disease (*Fig.* 455).

Lateral films should always be taken in inspiration and expiration. This will give some measure of the degree of paradox. In infants of course this is not possible. But the lateral film is a good record of the retraction at that time, and is valuable as a baseline for post-operative studies. In this series, apart from kyphosis, there have been no associated skeletal abnormalities.

All set measurements of either internal or external A.P. diameters are valueless unless put into small age groups. It is not measurements which matter because the deformity and its severity are apparent on clinical examination. Master and Stone (1949) state that you should diagnose an excavatum deformity only when the external A.P. diameter is less than 6½ in., but they do not specify in which age group. Certainly children up to 10 years of age do not average such large proportions.

In a series of 24 cases measurements were taken from the xiphisternal junction to the anterior aspect of the vertebral bodies, as shown in *Table I.*

From this table it is seen that the average measurement is less over 25 than in the other groups. This is simply because the deformity has reached its maximum by this age, and there is fixity, whereas in the younger group, fixity is not complete, and some films may not have been taken in full inspiration. Of course these adults were seen in a surgical unit and were adults who had a severe degree of deformity with symptoms.

INDICATIONS FOR SURGERY

Surgery is performed :—(1) To correct an unsightly deformity ; (2) To alleviate symptoms if they exist ; (3) To arrest the progression of a labile deformity if the clinical examination shows that this is inevitable.

A B

FIG. 456.—A, Typical Type II deformity. B, Same case one year post-operatively. While there has been improvement cosmetically there has not been complete eradication of the deformity.

These are the basic factors in the selection of cases, but some elaboration is necessary.

Surgery for cosmetic reasons should be undertaken if the deformity is severe enough ; whether this is necessary can readily be seen on examination. There are of course cases with a funnel deformity which are too mild, and the range of paradox of the sternum too limited to contemplate anything other than reassurance. Originally cases with symptoms only were selected, but as the cosmetic results have been observed the selection in this group has increased.

The cosmetic results vary and a more detailed description will be given later. Certain facts, however, may be stated now. A Type-I deformity may be operated on confident of obtaining a good result. In Type II a good result must not be expected, and at the best the deformity will only be corrected about 80 per cent, and sometimes less. The angulation is too far out and a degree of hollowing will be left, not as deep but as diffuse as before (*Fig.* 456). If the deformity is severe it should be corrected, but the patient or the parent should be told that complete eradication is not possible ; thus surgery in this group tends to be reserved for cases with symptoms, or where the deformity is marked. In Type III the results are better than Type II and near obliteration can be obtained. This is understandable because the angulation of the costal cartilages is usually close to the sternum.

In all patients with symptoms surgery should be performed, irrespective of their type. Sufficient follow-up records are available to make this categorical statement, and more details are given in the follow-up section.

A typical case may be quoted here : a male, aged 31, when originally seen, stated that all his life he was more easily 'puffed' than other boys, but he had led a normal life until three years ago, when he slowly developed dyspnœa of a distressing degree on moderate exertion. His work was that of a railway shunter, and when lifting the cup links from the trucks he would have to stop because of dyspnœa

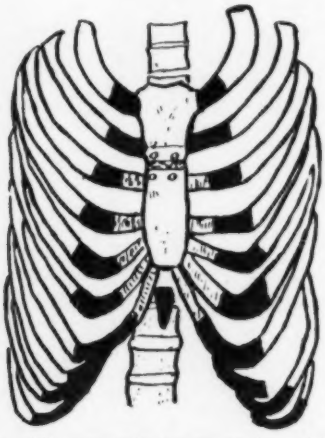


FIG. 457.—Diagrammatic representation of the operation, showing the site of the wedge osteotomy below the second costal cartilage. The site is fixed by drilling above and below the osteotomy and encircling it with thread sutures. The xiphoid is detached and the costal cartilages are removed subperichondrially. The 6th and 7th cartilage can be severed from the sternum and the portion resected. Any other perichondrial layers which stop the over-correction of the sternum should be detached from the sternum.

accompanied by severe precordial pain and syncope. He sought medical advice many times, and was most concerned because he felt he could not carry on with his work. A severe degree of Type I deformity was present. Operation was performed one year ago. He is now working full time and is completely unrestricted in his activities.

In babies, where the deformity is extremely mobile, on expiration there is no hollowing, but on deep inspiration the lower sternum is dragged well in. This is particularly well seen in laughing and crying. This is a funnel chest in the making, and is often noted by the parents for the first time whilst the child is being bathed.

Whether operation should be advised in the very young depends on the range of paradoxical movement of the lower sternum, and thus the degree of excavatum deformity produced. At this early stage, on relaxation, the sternum and the costal cartilage can regain their normal position, but, if persistent, some angulation of the sternum occurs even in expiration. There is now a mild deformity, even at rest. Progression occurs as life proceeds and the degree of the deformity will probably bear a direct relation to the degree of paradox.

These young patients should not be operated on before 3 months, as up to this age it is impossible to know whether paradox of the sternum is permanent. If persistent after this time and severe in degree, and particularly if there are episodes of pulmonary infection, then repair should be undertaken. To temporize is wrong and once any degree of sternal angulation at rest occurs, then to correct the deformity will require the more major procedure as opposed to the minor procedure which can be performed in these cases before any sternal angulation is present. Brodkin (1956) has stressed the importance of this. There is a temptation to defer operation at such an age, and I watched an infant until he was six months old, and by this time the sternal angulation had developed and the major operation was necessary. It was necessary because there was severe deformity on inspiration, angulation had occurred in three months, and the child had already suffered three attacks of bronchopneumonia.

Thus the selection of cases and the age at which to operate can be summarized as follows :—

1. Babies over 3 months, with severe paradoxical movement.

2. Children and adults with symptoms, irrespective of their type.

If the child is symptomless and a cosmetic repair is contemplated, it is preferable to wait until the fourth or fifth year, but earlier operation should be advised if bad posture is present. To attempt postural training without correcting the deformity is pointless, and eradication of bad posture can take a long time and needs persistence and patience. It is imperative in the post-operative period to train both the patient and the parent.

If the deformity is moderate and the range of paradoxical movement limited, it is preferable to see the patient at intervals and assess whether the deformity is progressing. Great importance is placed on the actual range of sternal retraction, and this gives a good guide to the likely course of the deformity. Such cases one or two years later may have reached their maximum degree of recession, and this may not be sufficient to correct either for cosmetic reasons or for any symptoms it may cause in later life.

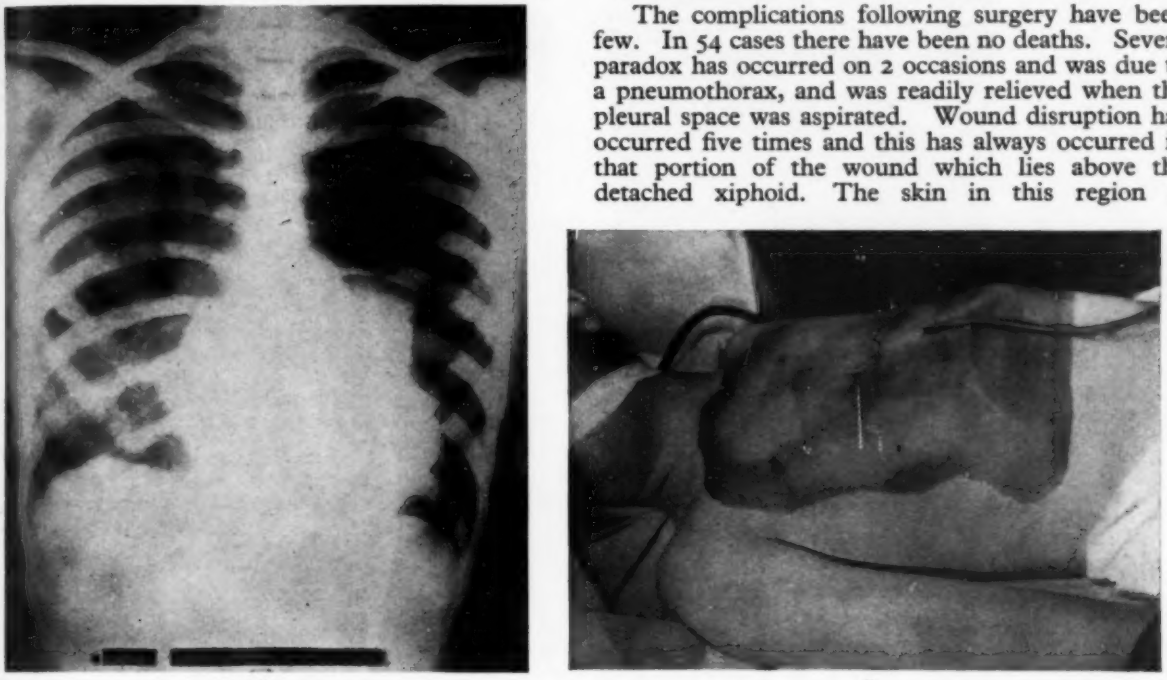
TECHNIQUE OF SURGICAL REPAIR

The basis of this has been described previously (Ravitch, 1949 ; Lester, 1954), and no point will be served in going into it in great detail. But certain features should be emphasized which are important :

1. **Modified Operation.**—This should only be performed when there is no deformity at rest. The object is to remove the anterior diaphragmatic attachment from the 6th and 7th costal cartilages and from the xiphoid. The 6th and 7th cartilages should be resected subperichondrially from 3–4 cm. and the perichondrium detached from the sternum, and the portion of the perichondrium adjacent to the sternum should be resected. The xiphoid should be detached from the sternum and buried by covering it with the upper portion of the rectus sheath. Both these manœuvres are desirable to prevent re-attachment of these structures to the sternum with subsequent recurrence of the deformity.

2. **Major Operation.**—The approach may be longitudinal or transverse, extending from the level of the 2nd costal cartilage to below the xiphoid if it is longitudinal, or extending to the nipple line at

about the level of the 4th or 5th costal cartilage if it is tranverse. The transverse incision gives an easier approach to the 6th and 7th costal cartilage. Anterior chest-wall incisions have more tendency to form keloid scars than incisions elsewhere in the chest wall. In this series both incisions have been tried and there seems to be no difference in the scar formation in either.



A B

FIG. 458.—A, Radiograph of a case which had not been connected to an underwater drain. The pleura had been jeopardized and an A.P. resulted. Such a state of affairs will produce severe paradoxical respiration. B, Showing drainage of the retrosternal space by dependent drainage. This tube was connected to an underwater seal.

The cartilage must be resected to just beyond the site of angulation, but this is not always possible in Type II. Any of the perichondrial layers which remain and which hold the sternum down should be severed from the sternum. The detached xiphoid must be covered by the rectus sheath, and the medial portion of the 6th and 7th cartilage be resected for the same reasons as stated above. I do not consider bone struts or wires desirable or necessary, but I consider it important that the site of the osteotomy be firmly fixed. Thus transverse osteotomy should be performed above the level of the angulation of the sternum. Simple periosteal sutures across the osteotomy may not hold, but if the sternum is drilled above and below the osteotomy, with two pairs of drill holes, and strong linen thread passed through these, with the sternum held in the overcorrected position, then secure fixation is obtained (*Fig.* 457).

The retrosternal space should always be drained to an underwater seal. This has two advantages: It avoids tension on the suture line from sero-sanguineous fluid, and it counteracts the danger of a pneumothorax if a small rent has been made in the pleura. A small hole in the pleura may not be recognized, and, if the patient is on open drainage, it will result in a pneumothorax, and severe paradox will occur (*Fig.* 458 A).

The only cases of severe paradox seen post-operatively both occurred when there was a pneumothorax. Neither of these cases was on underwater drainage, but this is now routine (*Fig.* 458 B).

COMPLICATIONS FOLLOWING SURGERY

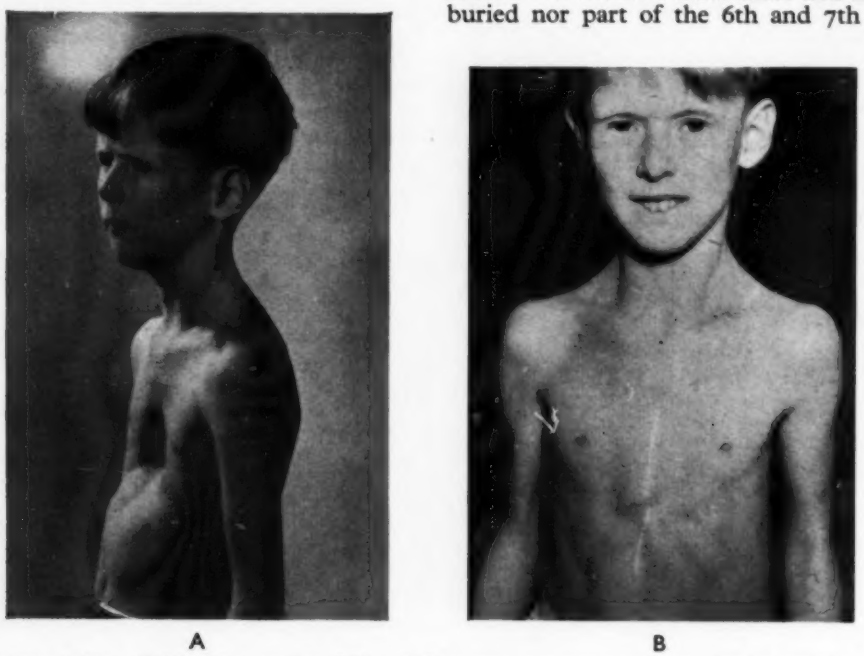
The complications following surgery have been few. In 54 cases there have been no deaths. Severe paradox has occurred on 2 occasions and was due to a pneumothorax, and was readily relieved when the pleural space was aspirated. Wound disruption has occurred five times and this has always occurred in that portion of the wound which lies above the detached xiphoid. The skin in this region is unsupported beneath, and if the wound gives it will always be at this site. All cases have healed to secondary suture.

FOLLOW-UP RESULTS

No case is considered in the follow-up group unless the repair was carried out six months previously. The series consists of 41 cases and has been divided into two main groups comprising those cases operated from 6 months to 2 years previously, and those over 2 years. It is important that the result of surgery, particularly from the cosmetic aspect, should not be assessed earlier than six months. It has been observed that there is a recurrence rate, and in some cases the position has altered from that seen when patients were discharged. The follow-up has attempted to assess two main factors—the cosmetic results and the symptomatic results.

1. Cosmetic Results.—Three features are taken into account: These are the persistence of any deformity, the presence or absence of paradox of the sternum on inspiration, and the posture of the patient. Any result which is given as 100 per cent means that no deformity persists, that there is no paradox of the sternum on inspiration, and that the posture is normal. In assessing the percentage of improvement post-operatively, recourse has been made in all cases to pre-operative photographs and radiographs. *Tables II–IV* show these results:—

Type I.—Of the 3 in the 90 per cent group, 2 had a small degree of paradox. Both cases in the 60 per cent group were classified as recurrences, and their ages were 19 months and 10 months, returned to the pre-operative degree of deformity. It was obvious that the xiphoid and the perichondrium of the 6th and 7th cartilage had re-attached to the sternum and thus the deformity was being reproduced. In none of these cases had the xiphoid been buried nor part of the 6th and 7th perichondrium



A B

FIG. 459.—A, Type I deformity pre-operatively. B, The same case two years later, showing complete and lasting obliteration of the deformity.

and paradox was present. *Fig.* 459 shows a typical result two years later.

Type II.—Paradox was present in 1 case with the 60 per cent improvement, and the 50 per cent improvement case was classified as a recurrence.

Table II.—COSMETIC RESULTS (*Type I.*)

	100 per cent	90 per cent	60 per cent
2 years or over	11	2	1
6 months to 2 years	8	1	1
Total	19	3	2

Table III.—COSMETIC RESULTS (*Type II.*)

	100 per cent	80 per cent	60 per cent	50 per cent
2 years or over	—	4	2	1
6 months to 2 years	1	5	—	—
Total	1	9	2	1

Type III.—No paradox occurred in any of this group.

Those cases classified as a recurrence have a deformity and a degree of paradox which resemble a case unoperated upon, though none of them resected. It is significant that the two frank recurrences, with only 60 per cent correction, were both in infants aged 19 months and 10 months, and it is particularly important in this young group to prevent re-adherence.

It can be readily seen that cosmetic results in Type I are better than in Type II. That is, out of 24 cases there were 19 with 100 per cent correction and 3 with 90 per cent correction; and in Type II, out of 13 cases there was only 1 with 100 per cent correction and 9 with 80 per cent correction.

The figures in Type III are too small to be significant, but I feel this group will give better

Table IV.—COSMETIC RESULTS (*Type III.*)

	100 per cent	90 per cent	80 per cent
2 years or over	—	—	1
6 months to 2 years	1	1	1
Total	1	1	2

results than Type II, as the angulation is closer to the sternum and the deformity is more localized.

Thus it is seen that cosmetically Type I gives excellent results. Type II at the best gives 80 per cent correction only, in most cases. The reasons for recurrence or failure to attain the maximum lasting result are due: (1) To re-attachment of the xiphoid and the perichondrium and the 6th and 7th

cartilage ; (2) To bending at the site of the osteotomy, by relying on periosteal sutures only, when firm fixation by drilling should be performed.

Symptomatic Follow-up.—In the 12 cases operated on for severe symptoms all have been cured. It should be stressed that these patients sought medical advice because they were disabled by their deformity to such an extent as to interfere with their leading a normal life.

The age range in this group is from 2 years to 37 years. Two only were under 10 years. In a child of 2 years recurrent chest infection was present of such severity that the patient's doctor felt he would not survive another winter. The other child was 7 years old, and whilst he was troubled by repeated chest infections, his main complaint was of dyspnœa of such a degree that he could enter into no games at all. The other 9 cases complained of dyspnœa on mild exertion, syncope, palpitations, and precordial pain on exercise.

The child aged 2 years has been through two winters with one cold only and recourse had not been made to his doctor since operation. The child 7 years old now swims and plays football—things he was unable to do before. The results have been just as consistently impressive in the remaining cases, and further comment has been made on two of these cases—a woman of 37 years, and a male of 31 years—earlier in this paper.

The conclusion can be made with confidence that surgery should be performed for symptoms, irrespective of the type of the deformity. In the milder group, whose symptoms were dyspnœa and chest infection sufficient to produce some disability but not disablement, good results have been obtained.

There are 19 cases in this group and all have been completely cured except one whose symptoms remain, yet the repair has been satisfactory.

The average age in the disabled group was 19·6 years, and in this milder group 9·4 years. It is interesting to speculate how many of these milder cases would have been increasingly troubled later on. Also if the group is broken down further, it is seen that respiratory infection predominates in the younger group, and dyspnœa predominates as they become older.

Those cases operated on for cosmetic reasons only and who deny any symptoms have been surprising. Of the 12 cases in this group, 8 have claimed definite physical benefit. The parents have maintained that the child is more active and alert, and " does much more ". No effort has been made to elicit this history, and when recorded it has been given spontaneously by the parent in more than one follow-up interview.

It can be seen that the relief of symptoms in all groups is almost certain, and, off-setting cosmetic results against symptomatic results, the latter are more satisfactory. But if the series consisted only of Type I deformity, then the results would be nearly comparable.

CONGENITAL STERNAL PROMINENCE

The condition of localized manubriosternal prominence, as shown in *Fig.* 440, will not be discussed. As yet I have not operated on such a case and they seem uncommon. The term ' pigeon chest ' should be reserved for this group, if such a name must be used.

The condition under discussion is often called pigeon chest, but a better name is congenital sternal prominence. It is illustrated in *Fig.* 441.

There is no doubt that it is a congenital deformity. As in funnel chest, the basic abnormality arises in the diaphragm, which causes secondary changes in the skeletal thorax.

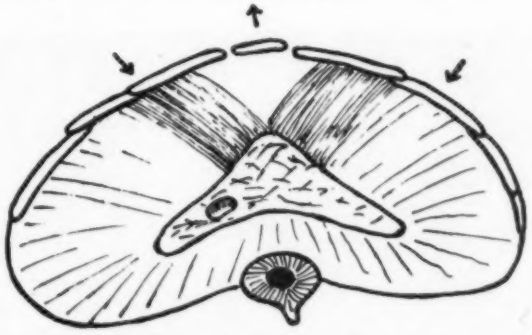


FIG. 460.—Diagrammatic representation of the abnormal anatomy in congenital sternal prominence. The anterolateral portion of the diaphragm is overdeveloped and causes recession of the chest wall on inspiration. There is lack of support to the lower sternum, owing to the abnormal attachment of the diaphragm anteriorly, and on inspiration the lower sternum shifts forward slightly due to two factors : (1) The lateral pull on either side ; and (2) Lack of fixation of the lower sternum.

Clinical examination of a series of 8 cases showed signs which were common to most of them, and were as follows :—

1. On deep inspiration the lower end of the sternum moves forward, the range of movement is limited but definite.

2. In all cases Harrison's grooves, or lateral sulci, were present, becoming accentuated on deep inspiration.

3. Synchronous with deep inspiratory effort is seen a dimpling in the rectus sheath, high up near the tip of the xiphoid.

The deduction made from these observations is that the anterior portion of the diaphragm is not attached normally to the xiphoid and the lower costal cartilage, but to the posterior aspect of the rectus sheath. In association with this there is probably over-developed muscle in the anterolateral portion of the diaphragm ; thus the lateral sulci, the dimpling of the rectus sheath, and forward displacement of the unsupported lower sternum can be explained. The reason for the sternal displacement needs further explanation. If the xiphoid and the lower costal cartilage were unsupported, the lateral muscles well developed, then on each inspiratory effort the lower sternum would tend to ride forward, simply because its lower tether was absent, being further aided by the posterior pull of the lateral component on either side squeezing it forward (*Fig.* 460).

These deductions were supposition only, and needed the support of an autopsy specimen. Such a specimen became available. A young man was seen who had a severe degree of sternal prominence. The diaphragm in this case is shown in *Fig.* 461. A careful dissection was performed and it was found that there was no diaphragmatic attachment to the

xiphoid or to the lower costal cartilages anteriorly. This area was occupied by fibro-fatty tissue which attached itself to the posterior rectus sheath. In the specimen displayed, the fibro-fatty tissue has been dissected away and the extent of the defective portion of the diaphragm can be seen.

Comparing this diaphragm with people of similar age, the lateral muscle component was over developed.

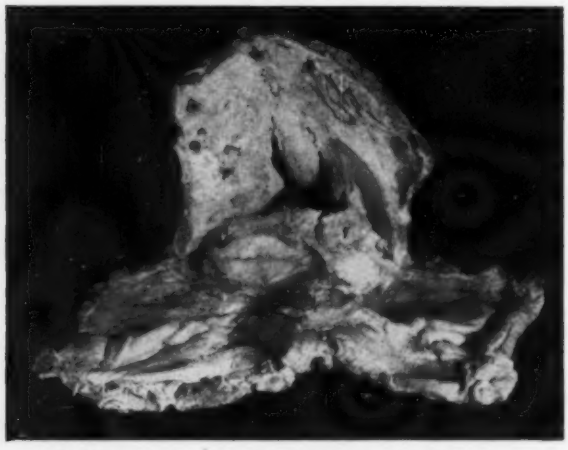


FIG. 461.—Photograph of the autopsy specimen viewed from the thoracic aspect. It is seen that the anterolateral portion of the diaphragm is well developed, but there is no attachment of the diaphragm to the inner portion of the subcostal margin nor to the xiphoid. In this case the anterior portion of the diaphragm is attached to the posterior rectus sheath and consists of a mass of fibro-fatty tissue.

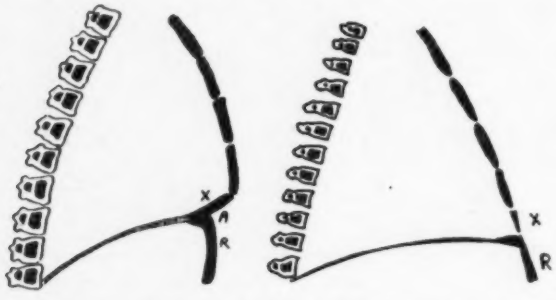


FIG. 463.—A, The anatomy in the infantile type, where the xiphoid is acutely angulated back and the diaphragm is attached partly to the rectus sheath and partly to the tip of the xiphoid. B, The quadrupedal type (*after Brodkin*). In this type the anterior diaphragmatic attachment is entirely to the posterior rectus sheath.

Brodkin (1953) has recorded a case of sternal prominence in which he had the opportunity to dissect the diaphragm. In his specimen the lateral portion was well developed, the central tendon was absent as such, and was replaced by a V-shaped area of fibrous tissue, which was thin and apparently attached to the xiphisternal junction. The basic feature in both these specimens was an abnormality in the diaphragm. However, the abnormality differed in each anteriorly, but the well-developed lateral component was common.

These findings are probably significant because there is a variation in degree and type of the sternal prominence. In spite of this, Harrison's grooves exist in all cases I have seen.

Fig. 462 shows the infantile or rotund type of chest. There is marked sternal prominence in this case; rectus dimpling and slight forward movement of the sternum were present, but it would appear that there is some attachment of the xiphoid as well as attachment of the rectus sheath, because in this type the xiphoid is acutely angulated backwards and the rectus dimpling on inspiration is not as readily seen and occurs in relation to the tip of the angulated xiphoid. It is reasonable to assume that in this

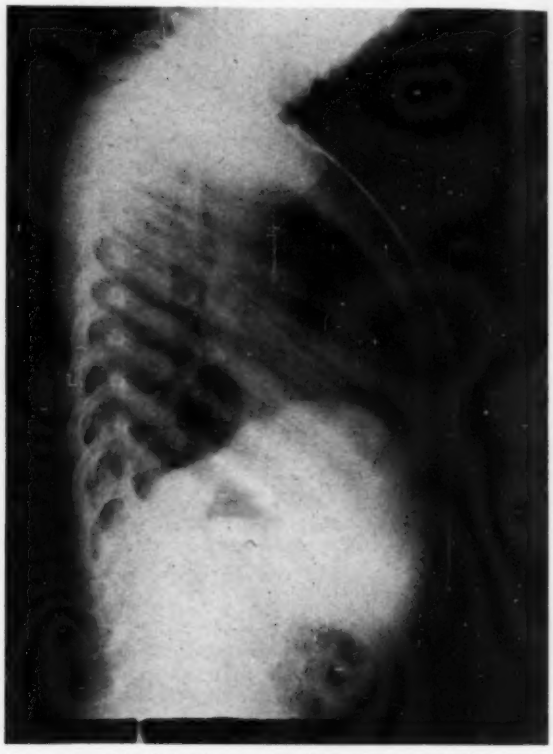


FIG. 462.—The infantile or rotund type of congenital sternal prominence.

type the abnormal anterior attachment is in part to the tip of the xiphoid and to the posterior rectus sheath.

Comparing this type with *Fig.* 439, a difference can be seen. The most prominent palpable structure is the xiphoid, and rectus dimpling on inspiration is readily seen below the xiphoid. The riding forward on inspiration is greater in these cases, as the xiphoid is completely unattached. In this type the anterior abnormal attachment is entirely to the posterior rectus sheath. Brodkin (1956) likens this type to the quadrupedal chest. The similarity is marked. The difference in the two types is shown in *Fig.* 463.

The abnormalities of the diaphragm existing in this type of deformity may well show further variations if only more specimens were available. From present evidence it would appear that a complete failure of the diaphragmatic attachment to the xiphoid and inner portion of the seventh costal cartilage leads to the quadripedal type of deformity, and partial attachment to the xiphoid and rectus sheath presents as the rotund type of deformity.

There is no physical disability from sternal prominence except perhaps if asthma is associated with the condition.

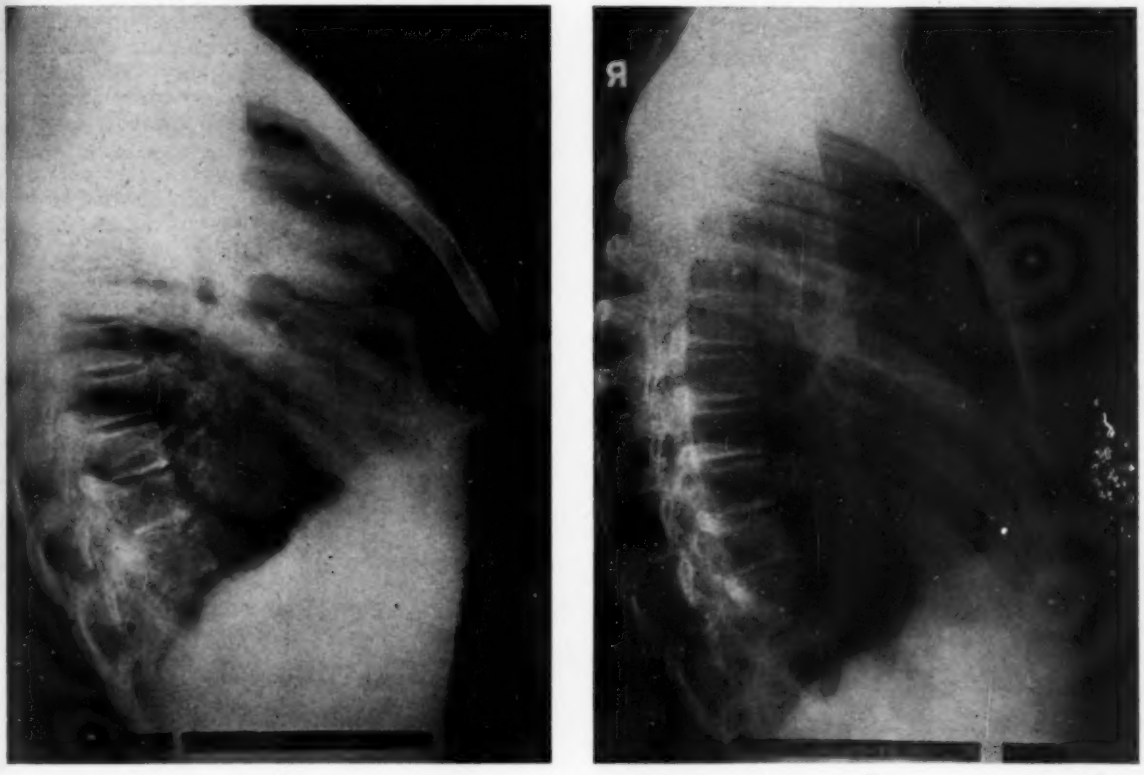
In a series of these cases two had asthma which was severe, and both these cases were of the second type. A photograph of one is shown (*Fig.* 441) and his radiograph is seen in *Fig.* 439. The case from which the autopsy specimen was obtained also suffered from severe asthma and died in status asthmaticus in his thirties. The question has arisen, when these conditions are associated, whether the abnormality is not due to asthma entirely. But the following evidence is against this :—

1. The deformity is seen often enough in cases without any such history.

where a xiphoid origin presented the bone was sharply angulated backwards from the anteriorly displaced sternum.

Cases have only been operated on where concern has been displayed by the patient over his deformity, or the parent has stated that the deformity is increasing. Unlike funnel chest, this deformity, I feel, produces no symptoms. Indications for repair are cosmetic only.

Both cases whose asthma was severe had a severe degree of deformity. It was hoped that by restoring nearly normal diaphragmatic action, their attacks



A B

FIG. 464.—A, Pre-operative radiograph of a boy aged 17 years with a severe degree of congenital sternal prominence. B, The same case two years later, showing the excellent result which may be obtained.

2. It has been observed in the early years of life in cases which have had no respiratory infections or troubles.

3. The autopsy specimen shows that there is a developmental failure of the diaphragm in part.

There is little doubt that asthma will accentuate the deformity and of course this applies to either funnel chest or sternal prominence equally. Respiratory tract obstruction in both conditions, whether due to nasopharyngeal obstruction or respiratory spasm, leads to accentuation of the deformity. Further evidence to support the preceding deductions has been found at operation. In the 8 surgical cases a simple dissection of the anterior diaphragmatic attachments was made. In 2 there was no xiphisternal origin of the diaphragm, but there was present a fibrous sheet attached to the posterior rectus sheath. In the remainder some slips of muscle arose from the tip of the xiphoid and the remainder from the rectus sheath. In the cases would be more easily tolerated. In one case it has made no difference, and in the other great symptomatic improvement has occurred. This is probably cortical, as the patient was intensely ashamed of his chest, and as an excellent cosmetic result has been obtained, he appears to have forgotten his asthma. Yet, on auscultation, marked bronchospasm is present.

This series is small, but significant enough to state that a good cosmetic result can be obtained in both types, and from this point of view, I feel that in a big series the results would surpass those of funnel chest. (*Fig.* 464.)

If a more extensive operation is to be avoided, then it is better to perform operation between 3 and 5 years, whilst the costal cartilages and the ribs are still flexible.

Seven cases have given excellent results, and in 3 cases between the ages of 2½ and 5 years the lateral grooves have obliterated. One case has given a

disappointing result—a child aged 7 years. The lateral grooves persist and there is still some sternal prominence, but the lower sternum no longer rides forward on inspiration. At least progression has been arrested, and this deformity may improve as the child grows. The reason for this failure is a technical one and will be discussed later.

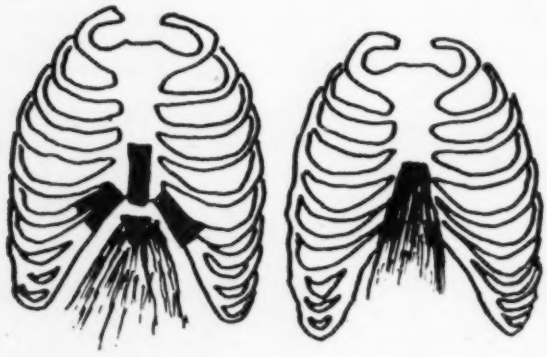


FIG. 465.—A, The xiphoid is detached from the sternum with the rectus sheath. The inner portion of the 6th and 7th costal cartilages is resected subperichondrially. A slot osteotomy is performed in the anterior portion of the sternum. B, The detached xiphoid, with the rectus sheath, is now sutured to the sternum at the level of the 4th costal cartilage.

THE OPERATION

This has been designed to give support to the lower sternum by attempting to restore the anatomy to normal. Because of the marked forward displacement of the lower sternum, the restoration must be overdone.

Basically the xiphoid is detached from the sternum and re-attached to the sternum at the level of the fourth costal cartilage, bringing with it any diaphragmatic fibres it may have, and the upper rectus sheath. This degree of displacement puts the portion of the rectus sheath that has the abnormal diaphragmatic attachment to the lower level of the sternum.

To allow this shift it is necessary to perform a subperichondrial resection of the 6th and 7th costal cartilage. It is better to make a slot along the front of the sternum so that the xiphoid does not create a lump under the scar. Fixation should be by drill holes and 25 linen thread (*Fig.* 465).

In children between the ages of 3 and 5 years this is all that is necessary, as the costal cartilage and ribs are supple enough to aline themselves to their new position.

In older patients the operation will need to be extended. It will be necessary to perform a subperichondrial resection of costal cartilages from the 4th to the 7th, before a proper alinement can be obtained. In two patients, aged 14 and 17 years, besides subperichondrial resection of part of the costal cartilage from the 3rd to the 7th, osteotomies were necessary in the remaining portions to prevent pallisading of the ends of the costal cartilages, owing to the marked backward retraction of the sternum.

Thus, once the xiphoid with the rectus is attached, the sternum moves backwards. The costal cartilages then have to be alined to the sternum, and this may mean a subperichondrial resection of a varying number. If pallisading occurs, osteotomies will be necessary.

The reason for the failure in one case was due to not carrying the xiphoid high enough up the sternum and thereby only partly correcting the abnormality.

This operation is tolerated very well, and in this small series there have been no complications. A further five cases have been operated on with excellent cosmetic results.

The author wishes to express his thanks to W. Somerville, M.D., who carried out the electrocardiographic studies.

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TWO CASES OF SPINAL ABNORMALITY ASSOCIATED WITH DUPLICATION OF THE GUT AND MELÆNA

A REVIEW OF THE THEORIES CONCERNING THEIR ORIGIN

By KEITH D. ROBERTS and MARY M. WEEKS

FROM THE CHILDREN'S HOSPITAL, BIRMINGHAM

CONGENITAL abnormalities are often multiple, and duplication cysts of the alimentary tract are no exception. These two cases of multiple abnormalities show that a single developmental defect may account for apparently disconnected conditions.

CASE REPORTS

Case 1.—C. M., a male baby, born three weeks prematurely, birth weight 6 lb. 2 oz., was admitted to the Children's Hospital, Birmingham, on Feb. 11, 1955, at the age of 7 weeks. His progress had been normal until 4 weeks, when he developed a persistent cough; at 6 weeks attacks of colic, associated with vomiting, dyspnœa during and after his feeds, and loss of weight, developed.

ON EXAMINATION.—He was a well-nourished baby, of 8 lb. 8 oz. Temperature 99° F., respirations 64, pulse 140. The trachea was deviated to the right, and there was an impaired percussion note and diminution of air entry over the left upper and right lower lobes. Rib recession was marked and when the infant was raised inspiratory stridor was obvious. Abdominal and rectal examination revealed no abnormality.

Radiography.—A straight radiograph showed the presence of a large, rounded opacity in the left upper chest, displacing and compressing the trachea anteriorly and to the right. The left bronchus was stretched around the periphery of the mass inferiorly and the left lower lobe was collapsed. A second and slightly larger opacity was seen in the right lower chest (*Fig.* 466). A lipiodol swallow showed that the œsophagus was displaced anteriorly and to the right by the lower mass and that compression had produced almost complete œsophageal obstruction (*Fig.* 467).

The probable diagnosis was that of duplication cyst (or cysts) of the foregut, and the partial tracheal obstruction demanded urgent surgical relief.

AT OPERATION (Feb. 12, 1955) (K. D. R.).—Under thiopentone and tubocurarine anæsthesia with endotracheal nitrous-oxide and oxygen. With the patient in the lateral position, the left pleural cavity was entered through the fourth intercostal space. The lung was displaced forwards by a tense mediastinal cyst presenting posteriorly; this was aspirated, producing 120 ml. of clear mucoid fluid. The mediastinal pleura was incised and the cyst freed from the thoracic inlet, where it began blindly, being adherent to the œsophagus. The cyst was mobilized and found to track downwards and pass medially behind the aorta. It then passed forwards and downwards, and further dissection was facilitated by a second incision in the seventh intercostal space. The cyst ended blindly in the œsophageal hiatus. The right mediastinal pleura was opened and the right pleural cavity palpated, but no further cyst was found. The chest was closed without drainage.

PATHOLOGICAL REPORT.—An L-shaped tube, 10 cm. in length, with a bend 6 cm. from the proximal end, presenting a tuberous swelling at the proximal end with a diameter of 4·5 cm. separated by a deep groove from the distal end. The latter had a diameter of 2·2 cm. before the bend and showed a fusiform narrowing towards the distal end, which was only 0·5 cm. in diameter. The cyst was covered by a thin and translucent membrane with numerous dilated blood-vessels, under which pinkish-grey tissue was seen. The wall was 2 mm. in thickness and greyish-white in colour. The inner lining was a smooth and lustrous greyish-white membrane, within which ovoid, shallow depressions, sharply demarcated, surrounded by slightly prominent trabeculæ, finely granular in appearance, greyish-red and dark red in colour, were seen. In addition there were a few submucous hæmorrhages translucent through the inner lining, 2–5 mm. in diameter (*Figs.* 468, 469).

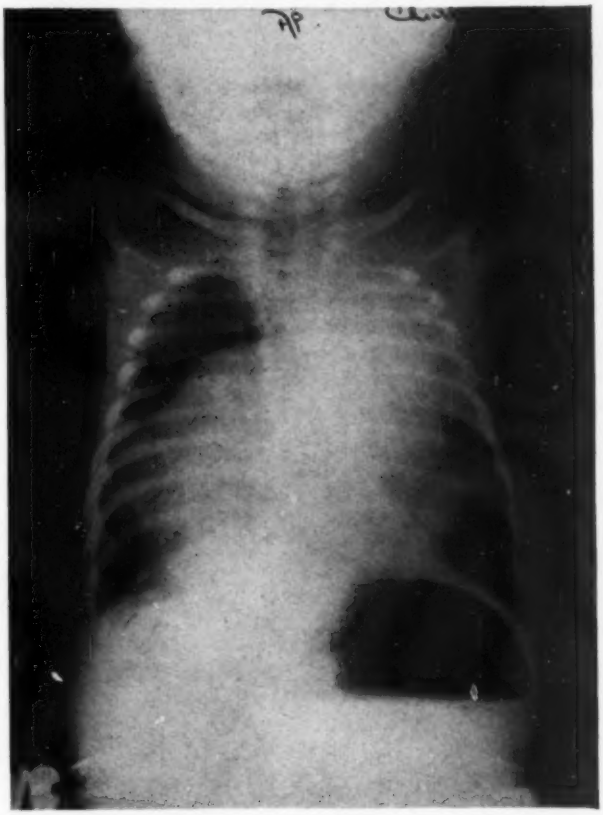

FIG. 466.—*Case* 1. Anteroposterior radiograph showing opacities in left upper and right lower chest with atelectasis of the left lower lobe.

Histology.—The wall showed a longitudinal and a circular muscular coat. In addition there was in some areas an oblique muscular coat. The mucosa in the proximal part had a partly ciliated columnar epithelium, partly a stratified squamous epithelium. In this area there were also mucous glands like those of the œsophagus. The middle and distal parts were lined by gastric mucosa, either fundal or cardiac in type (*Fig.* 470).

The baby's post-operative progress was uneventful and he was discharged four weeks after operation, free from symptoms.

ON RE-ADMISSION.—On May 12, 1955, then aged 20 weeks, he was re-admitted, having had melæna for one week, and having refused his feeds for four days; there had been no vomiting and no respiratory symptoms.

ON EXAMINATION.—He weighed 16 lb. 14 oz. and was pale, but there were no abnormal physical findings. Temperature 98° F., respirations 40, pulse 110. The stools were black and the test for occult blood was strongly positive.

Blood-count (May 13).—Red blood-cells 3·4 million/c.mm. Hæmoglobin 8·6 g. per cent; White blood-cells 10,000/c.mm.

Radiography.—A barium meal suggested the presence of a malrotation of the gut, and barium enema confirmed this, showing the cæcum to be lying in the left hypochondrium.

In view of the possibility of a duplication of the small intestine a laparotomy was thought advisable.

AT OPERATION (May 25, 1955) (K. D. R.).—Under thiopentone and tubocurarine anæsthesia with endotracheal nitrous-oxide and oxygen, a right paramedian laparotomy was done. The ascending and transverse colon had a free mesentery, and the cæcum lay in the left hypochondrium. A duplication 10 cm. long was found just distal to the

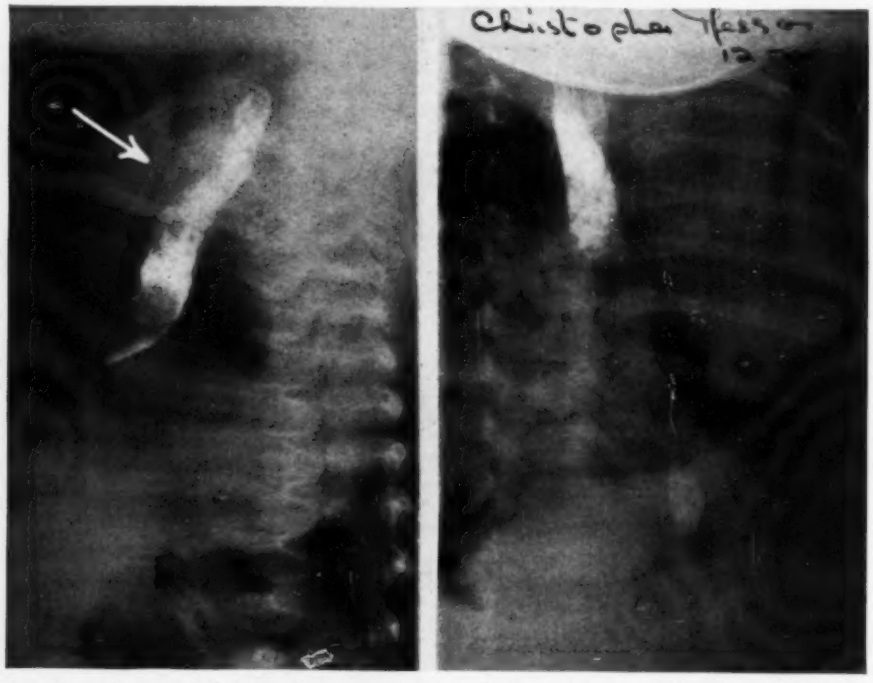

FIG. 467.—*Case* 1. Lipiodol swallow—note œsophageal obstruction and marked narrowing of the trachea shown by the arrow.

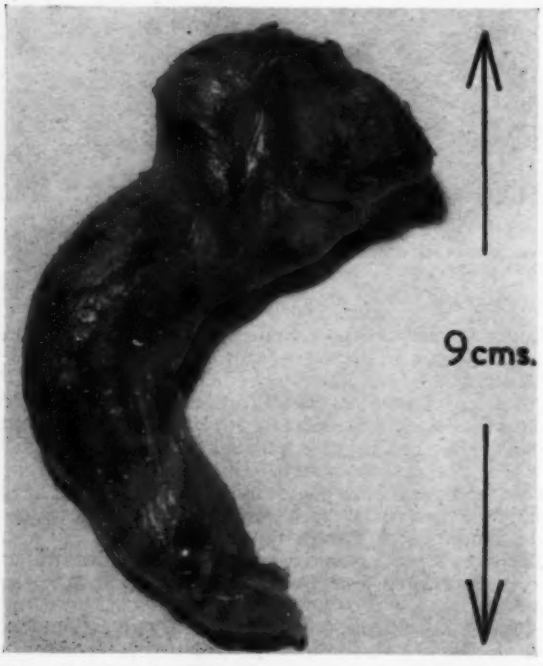

FIG. 468.—*Case* 1. The specimen as it lay in the chest; note the groove caused by the aorta (first operation).

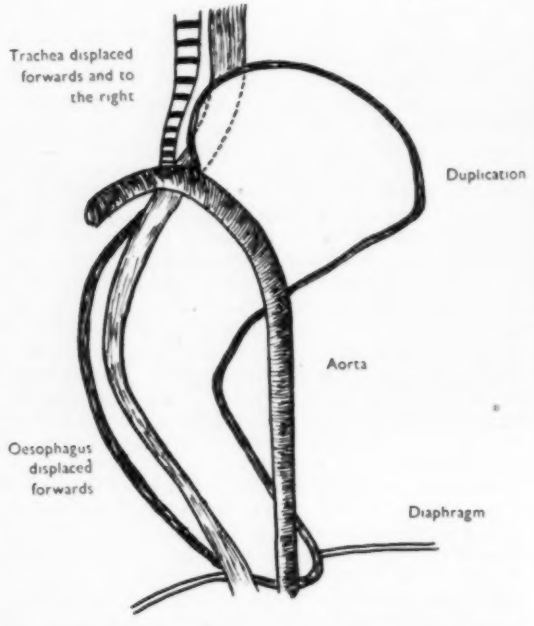

FIG. 469.—*Case* 1. Diagrammatic representation of the relations of the cyst.

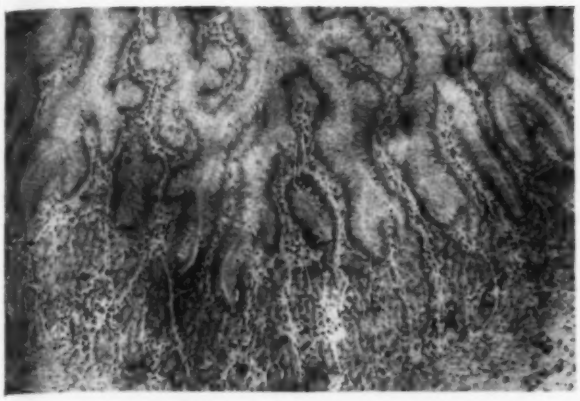

FIG. 470.—*Case* 1. Section of the cyst showing an area lined by fundus-type gastric mucosa.

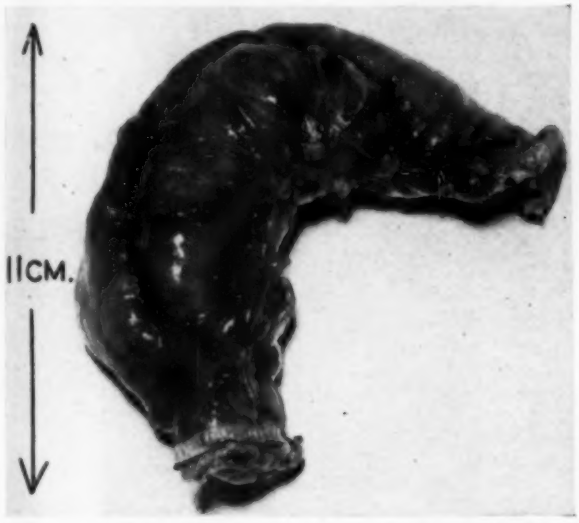

FIG. 471.—*Case* 1. The excised segment of jejunum with the duplication (second operation).

1·25 cm. in diameter. This tube was completely separated from the intestine, but lined by a mucosa of the same appearance as that of the intestine. On cross-section this tube proved to consist of two parallel tubes, the larger one 1 cm. in diameter the smaller 0·25 cm. in diameter, but of the same length (*Fig.* 471).

Histology.—The duplications were lined by gastric mucosa of the fundus type, but the arrangement of the muscular coats was the same as in the intestine. Red blood-cells were seen in the lumen (*Fig.* 472).

The baby's convalescence was again uneventful and he was discharged two weeks after operation. His subsequent attendance as an out-patient has revealed no further symptoms, but in view of the known possibility of

FIG. 473.—*Case* 1. Radiograph of the spine showing spina bifida from C.2–T.2.

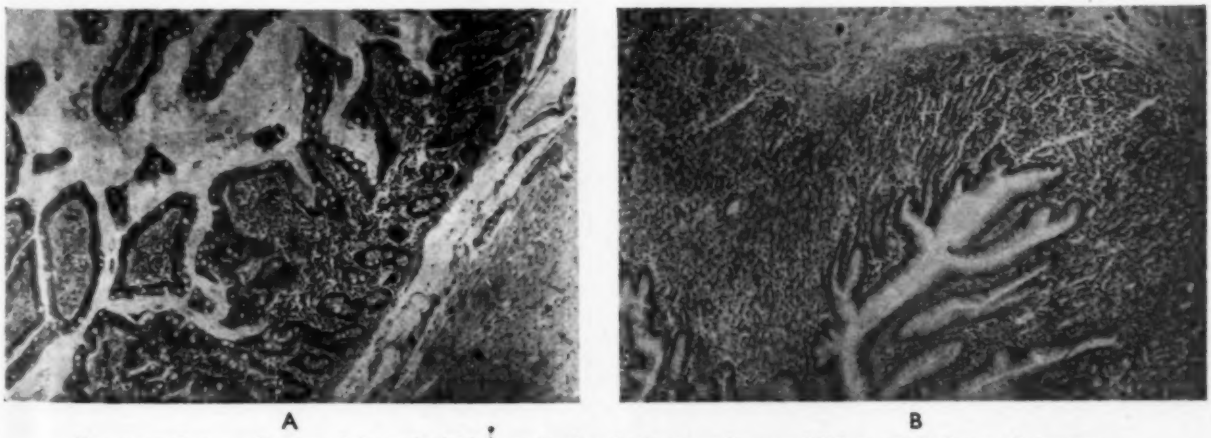

FIG. 472.—*Case* 1. Section of the excised jejunum showing A, the normal mucosal lining, and B the gastric mucosa fundus type lining the duplication.

duodenojejunal flexure; the segment of jejunum was excised and an end-to-end anastomosis done in two layers. The appendix was removed and the abdomen closed.

PATHOLOGICAL REPORT.—A segment of small intestine 11·5 cm. in length, 3·5 cm. in circumference. Attached to the mesenteric border was a tube 5 cm. in length,

associated foregut duplications, a radiograph of his spine was taken, showing a spina bifida of C.2–T.2; C.6 had a large vertebral body that was bifid in the sagittal plane and also partially divided transversely into upper and lower portions by a groove on its anterior aspect; C.5 and C.7 had small and slightly malformed bodies (*Fig.* 473).

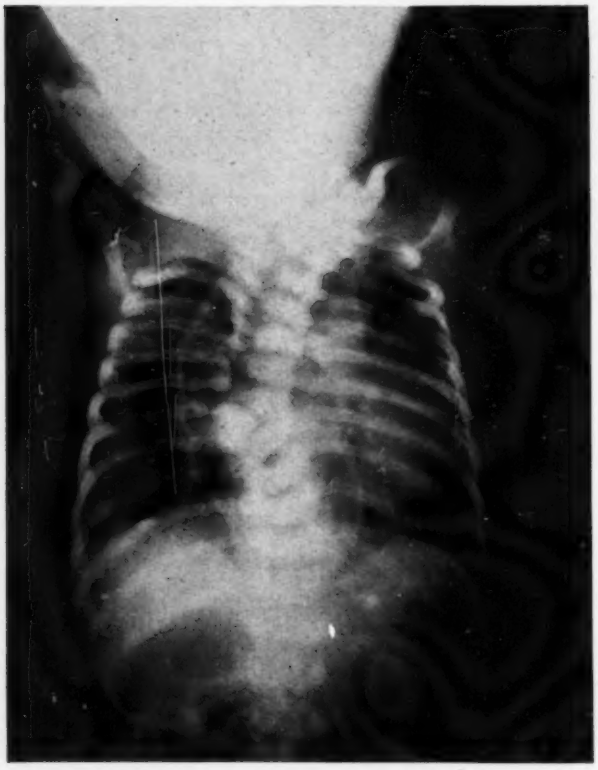

FIG. 474.—*Case* 2. Anteroposterior radiograph showing mediastinal gas shadow and spinal abnormality.

FIG. 476.—*Case* 2. Lateral radiograph after a barium meal, showing the duplication filling and communicating with the jejunum.

Case 2.—D. E., a male baby, aged 18 weeks, was admitted to Hill Top Thoracic Surgical Unit, Bromsgrove, on Feb. 22, 1956. He was a full-term baby of birth weight 9 lb. 2 oz. At the age of 4 weeks he had had an excision of a cervical myelocele by Mr. Eric Turner at the Queen Elizabeth Hospital, Birmingham. When 9 weeks old he had been treated for a respiratory tract infection, at which time radiological examination disclosed the presence of intestine in his chest. Prior to admission to the Thoracic Unit he had had melæna for five days.

ON EXAMINATION.—He was a pale infant, not dehydrated, with obvious mild hydrocephalus and

FIG. 475.—*Case* 2. Barium swallow showing normal position of œsophagus and cardia.

mental abnormality. Temperature 100° F., respirations 50, pulse 130. Weight 12 lb. There was a palpable defect in the vertebral arches of the cervicodorsal region with a well-marked kyphoscoliosis. The chest and abdomen showed no abnormal physical signs, and rectal examination was normal apart from the presence of melæna. The test for occult blood was strongly positive.

Blood-count (*Feb.* 23).—Red blood-cells 1·88 million/c.mm.; Hæmoglobin 61 g. per cent; White blood-cells 12,500/c.mm.

Radiography.—There was a deformity of the thoracic cage associated with a congenital abnormality of the spine; the seventh thoracic vertebra was represented by a right-sided hemivertebra with corresponding scoliosis, costal abnormalities, and mediastinal shift to the left; there was a more severe congenital abnormality of the cervical spine with spina bifida.

In the mediastinum there was a gaseous translucency that extended from the level of the thoracic inlet down to the diaphragm. On the right it extended out into the lung field and was limited by a vertical curving line that

ran about 0·5 cm. lateral to the right border of the spine and roughly parallel with it. On the left there was a somewhat similar vertical limit, seen through the shadow of the heart (*Fig.* 474). In other chest pictures there was opacity in the lower part of the previously translucent area, with a horizontal fluid level. At first glance the appearances resembled those of a hugely dilated œsophagus containing fluid. The diaphragm and upper abdominal

It was considered that the baby had an unusual type of diaphragmatic hernia, in addition to which there was probably a duplication of the small intestine accounting for the melæna. Two transfusions of packed cells were given to prepare him for operation, but he developed

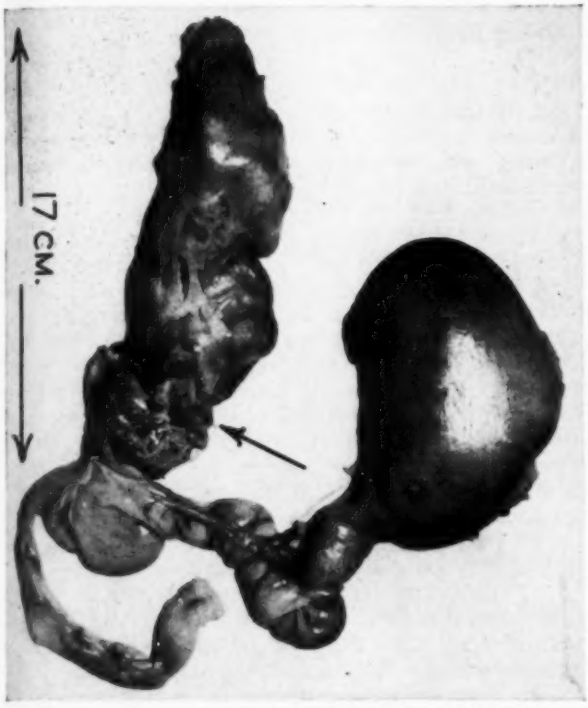

FIG. 477.—*Case* 2. The duplication joining the jejunum; the diaphragmatic muscle is indicated by the arrow.

FIG. 478.—*Case* 2. The opened duplication, showing the peptic ulceration.

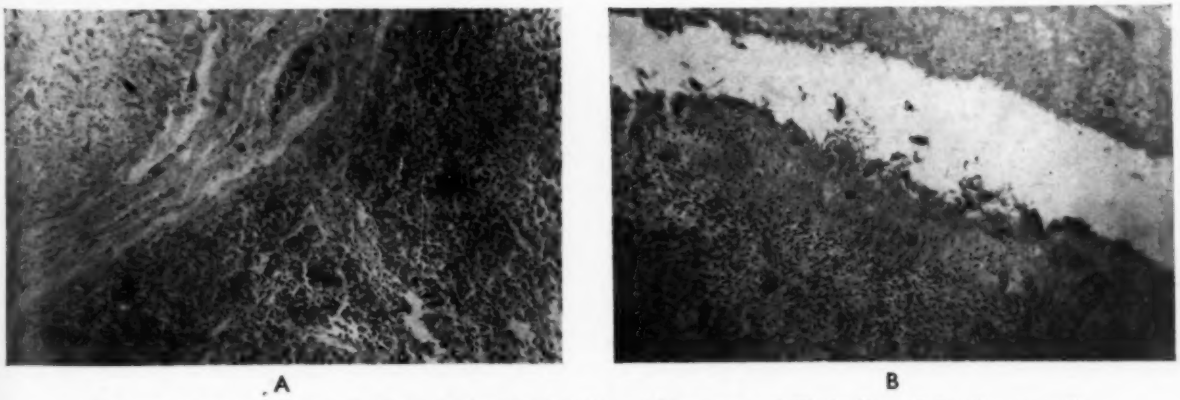

FIG. 479.—*Case* 2. Section of the duplication showing (A) gastric mucosa and (B) the floor of the ulcer, smooth muscle, and exudate.

gas shadows appeared normal. The pulmonary markings were prominent, but there was no gross respiratory infection.

Barium Studies.—The œsophagus appeared somewhat displaced anteriorly by the gas and fluid-containing mass, but in other respects it was normal (*Fig.* 475). The stomach was normally situated, but it emptied into a dilated loop of small intestine lying high up in the right hypochondrium close to the diaphragm. From this loop the main bulk of the barium passed normally down the alimentary tract, but considerable amounts also passed upwards into the midline thoracic mass (*Fig.* 476).

bronchopneumonia and died on March 5, before laparotomy had been done.

POST-MORTEM EXAMINATION.—This showed that there was a duplication cyst in the posterior mediastinum, very adherent to the upper thoracic vertebræ in the region of the vertebral abnormalities (posterior spina bifida with kyphoscoliosis). The duplication passed posteriorly to the median arcuate ligament to join the jejunum in the region of the duodenojejunal flexure (*Fig.* 477). There was also a malrotation of the gut, the cæcum and appendix lying in the left hypochondrium. No diaphragmatic hernia was present.

PATHOLOGICAL REPORT.—A segment of duodenum and part of the jejunum; duodenum + segment of jejunum 35 cm. in length; 16 cm. distal to the pylorus an opened cystic body was attached. This cystic body showed two parts, different in appearance, of the lining, the one attached directly to the jejunum was 7 cm. in length and 2 cm. in circumference; it had a smooth mucosal lining without plicæ of Kerkring. The other, which from the situation of the fragment of diaphragm attached to it, was intrathoracic and 10·5 cm. in length, 5·5 cm. in circumference. Its mucosal lining showed numerous oblique folds. At the junction of the two parts was a triangular ulcer 2 cm. in length. The margins of the ulcer were elevated, rounded, and formed by firm, pinkish-grey, and greyish-white tissue. The floor was clean, smooth, and yellowish-white (*Figs.* 477, 478).

Histology.—The 'cyst' had a wall with the structure of an intestinal wall; there was a longitudinal and a circular muscular coat, nerve-cells of myenteric plexus and submucous plexus. The mucosa, however, was of the gastric type with fundus glands. The floor of the ulcer showed some fibrin and abundant granulation tissue which undermined the surrounding mucosa. (*Fig.* 479.)

COMMENT

Duplication cyst of the mediastinum was first noted by von Wyss (1870), and Roth (1881) reported the firm adhesion of a mediastinal enteric cyst to the vertebral column in a patient who also had an intramesenteric cyst and an ileal duplication.

Ware and Conrad (1953) reviewed the literature, finding 81 cases of intrathoracic enteric cyst; of these, 18 had spinal abnormalities, 3 had associated small intestinal duplication, and 1 had a malrotation of the gut. Fallon, Gordon, and Lendrum (1954), discussing 61 previously recorded cases, found vertebral abnormalities in 18 (spina bifida anterior, hemivertebræ, or infantile scoliosis) and noted that the incidence was probably higher than this as the cyst may be caudad to the spinal condition so that the necessity for radiography of the cervical and upper thoracic spine may not be appreciated; moreover, Veeneklaas (1952) found that tomography was necessary to reveal some vertebral deformities. Fallon and others (1954) recorded 2 cases of mediastinal cyst, one associated with fusion of cervical vertebral bodies, the other with posterior spina bifida.

Orban and Honoré (1954) described a child aged 6 months, initially treated by excision of a duplication of the œsophagus, and three months later by resection of an ileal duplication which communicated with the peritoneal cavity and had caused ascites.

Mestitz (1955) reported a child aged 6 months with a duplication of the œsophagus treated by excision; at the age of 2 months and 3 months the child had had melæna, and this recurred twelve days after the operation. There was also a spina bifida, so that he considered there was a strong possibility of an intestinal duplication, although no laparotomy was done.

The symptoms of mediastinal duplication cyst may be due to tracheobronchial and/or œsophageal compression, or to erosion of the lung or œsophagus by the cyst. Thus the patient may have dyspnœa, stridor, dysphagia, hæmoptysis, or hæmatemesis, or a combination of these. Gross (1953) stated that rapidly growing cysts in infancy are usually lined by gastric mucosa which secretes fluid with a high pepsin and hydrochloric acid content, sometimes producing ulceration and fistulæ into the lung or œsophagus; he also found that thoracic duplications communicating with the intestine were rare (3 cases, Gross, Neuhauser, and Longino, 1950) and might produce symptoms due to distension with air or fluid, or exsanguinating melæna due to peptic ulceration as the cyst might be lined in part by gastric mucosa. Fisher (1950) also recorded a mediastinal duplication communicating with the intestine.

Large mediastinal cysts causing respiratory embarrassment demand urgent surgical relief (Leahy and Butsch, 1949); as an emergency pre-operative measure aspiration of the cyst may be necessary (Lowry and Moorman, 1938), but early excision is then indicated in view of the possibility of leakage of irritant fluid into the mediastinal tissues.

In childhood the passage of a tarry stool or one strongly positive to the test for occult blood may be due to peptic ulceration, œsophagitis, portal hypertension, or ulceration in a Meckel's diverticulum. Conditions such as polyps, intussusception, bacillary dysentery, hæmorrhagic disease of the newborn, and blood dyscrasias, usually cause the passage of frank blood per rectum. A radiograph of the chest may provide useful information (Normark, 1938), as the presence of a posterior mediastinal cyst (or of vertebral abnormalities) might lead to the suspicion of a communicating gastric-lined intestinal duplication.

Embryology.—Mediastinal cysts of foregut origin may be classified into three groups:—

1. Intramural œsophageal cysts, which all have a ciliated epithelium, and lie within the wall of the œsophagus; they may be of the same nature as accessory lungs (Baar and d'Abreu, 1950).

2. True bronchiogenic cysts, which always lie within the lung or in association with the main bronchi, usually are lined by ciliated epithelium and may or may not have cartilaginous elements in their walls.

3. Enteric cysts, arising from cells of the foregut already determined for the formation of alimentary tract; the lining is gastric or intestinal mucosa and there is a well-developed muscularis mucosæ with two or three main muscle coats.

The presence of ciliated epithelium gives no indication of the origin of the cyst; the first two groups are distinguished more from their position than from their histology, while the high degree of differentiation of the third group enables such cysts to be classified as of enteric origin.

Theories of formation of mediastinal enteric cysts and intestinal duplications include an origin from Meckel's duct (which is scarcely tenable in the case of duplications high in the alimentary tract); the formation of cell nests from the primitive alimentary tract, which later grow to form diverticula (Lewis and Thyng, 1907); the failure of some vacuoles to join up with the main intestinal tube following the vacuolation of the solid primordium of the canal (Bremer, 1944). All the above theories fail to account for the high incidence of coexisting vertebral abnormalities.

Veeneklaas (1952) put forward the theory that, if separation of the notochord from the entoderm is not complete, a pouch of the latter could be withdrawn from the primitive alimentary tract into the

mesodermal anlage of the vertebral bodies. Such a pouch could then grow to form a mediastinal (or intestinal) duplication which may or may not communicate with the alimentary tract, while the column of cells attaching the pouch to the notochord may interfere with the proper development of the vertebral bodies or cause failure of fusion of the vertebral arches. This theory is fully discussed by Fallon and others (1954), and would appear to account for the abnormalities present in the two cases reported in the present paper excepting the malrotation of the gut. In *Case* 1 the melæna is difficult to explain in view of the non-communication of the intestinal duplication with the normal bowel.

SUMMARY

Two cases are reported, the first presenting initially as œsophageal and respiratory obstruction at the age of 7 weeks (believed to be the youngest recorded in this country) due to a mediastinal duplication cyst, and later with melæna due to a jejunal duplication. The second case showed exsanguinating melæna due to a mediastinal duplication communicating with the jejunum. Both patients had associated spinal abnormalities and malrotation of the gut.

The literature is reviewed and the symptoms, treatment, and pathogenesis of such duplications are discussed.

We are indebted to Professor J. M. Smellie for permission to report *Case* 1; to Mr. A. L. d'Abreu for *Case* 2, which was referred by Dr. L. M. T. Masterman of Selly Oak Hospital, Birmingham; and to Professor F. A. R. Stammers for his advice in the preparation of this paper. Our thanks are also due to Dr. Roy Astley and Dr. D. I. Harries for the radiological examinations; Dr. H. S. Baar for the pathological reports; and Mr. J. G. Williamson for the photographs.

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SPONTANEOUS PERFORATION OF PELVIC COLON

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PERFORATION of the colon or rectum occurring in the absence of any recognized cause or predisposing factor is an unusual event. When bowel is healthy, rupture or perforation most commonly arises as a result of injury either from outside or from within the lumen, but diseased bowel may give way during muscular effort or, even, seemingly spontaneously. That healthy bowel too, in the pelvirectal region or elsewhere, may sometimes be ruptured by muscular effort is well known; thus Aird (1949) speaks of rupture of the rectum having "sometimes followed straining at stool, the lifting of heavy loads and childbirth"; such an occurrence is particularly well illustrated by Huntley's report in 1919 of an Army officer who sustained a laceration of his colon whilst straining violently during defæcation. So far as I know there is only one record of what would appear to have been a truly spontaneous perforation of undiseased pelvic colon; that was given by Brown (1944) when he wrote of a 30-year-old male who, shortly after rising from bed, was seized "without apparent cause" with very severe hypogastric pain which was soon proved at operation to have been caused by a laceration of his colon about 1 cm. long on the anterior surface of the bowel near the pelvirectal junction. Weinstein and Roberts (1952) regarded the case they described as being in the same category, but it seems doubtful if they were justified in doing so since their patient perforated his colon while having a bowel movement which "had required more than usual straining". Eadie (1955) cited Brown's case and that of Weinstein and Roberts, along with two others from the literature (Hahn, 1931; Lataix, 1949), as examples of spontaneous perforation of macroscopically normal colon, and to these he added the record of a patient of his own. But in three of these there is a story of straining at stool when the pain came on; only in Lataix's case, as in Brown's, is this factor absent; and the presence in the former of a large incisional hernia may be thought to have been aetiologically significant.

Two cases are reported in this paper which are thought to be similar to Brown's in that perforation of apparently healthy pelvic colon occurred without the agency of any muscular, or other, violence and in the absence of any obvious hernia.

CASE REPORTS

Case 1.—Mrs. M. L., aged 38 years, was admitted to hospital on Nov. 28, 1951. She was complaining of hypogastric pain of about three days' duration; her temperature was 98°, her pulse-rate 84 per minute, and

her respiratory rate 28 per minute. A nervous, garrulous woman with a previous history of dyspepsia, she gave a very detailed account of her illness, stating that it had begun fourteen days previously with sudden severe epigastric pain, spasms of which had recurred at half-hourly intervals during the next ten days; she had vomited during every spasm. Three days before admission another pain had developed which was described as a severe colic situated in the umbilical region, but later that same day this pain had settled in the suprapubic area. Occasional vomiting had occurred until the day before admission, but her appetite, surprisingly enough, had been "fair". She had had no diarrhœa and no pain during defæcation; she had had no enemata. Fourteen months earlier she had had cholecystectomy and division of an aberrant right renal vessel done in another hospital.

On Admission.—The patient did not appear to be seriously ill, her tongue was clean, her abdomen was not distended or rigid, and she was not obviously dehydrated. There was diffuse tenderness in the lower abdomen and some resistance to palpation there. Some firm scybalous fæces were felt in the rectum. Her blood-pressure was 104/60 and her white blood-cell count 11,800 per c.mm. Some hours after admission her temperature rose to 100·8° and she complained of hypogastric pain, but there was no significant change in the abdominal signs. Next day she started to menstruate; the temperature had returned to normal, but it now seemed that a mass might be developing in the suprapubic region to the left of the midline. During the next twenty-four hours (Nov. 29–30) there was no appreciable alteration in the clinical picture; the patient still complained from time to time of spasms of lower abdominal pain but it was thought that she probably exaggerated these. By the morning of Nov. 30 there seemed no doubt that there was a mass deep in the left iliac fossa. It was therefore decided to subject her to laparotomy. The bowels had not moved since admission, and a small and very gentle enema was therefore given. The enema produced no result and did not bring about any change in the patient's symptoms or signs.

At Operation.—A hole, approximately circular and about 1½ in. in diameter, was found in the sigmoid colon on its anterior surface; the bowel otherwise appeared normal and there was astonishingly little inflammatory reaction even at the margin of the defect or on the intestinal loop which had been adherent to it. The lumen of the gut was filled with firm, but not hard, fæcal material which was blocking the perforation; remarkably little soiling of the peritoneal cavity had occurred though there was some local pelvic peritonitis. There was no sign of any intraperitoneal foreign body. The affected loop of bowel was exteriorized as a colostomy and the laparotomy wound drained.

Progress.—The patient's progress after operation was smooth and in due course the exteriorized loop was resected and end-to-end anastomosis performed. She was dismissed on Jan. 4, 1952, by which time her general condition was good and her bowels were moving quite normally. Histological examination of the excised portion of bowel threw no light on the cause of the perforation—nor did examination of a biopsy specimen taken from the edge of the hole at the original operation. It is appreciated that the fact that an enema, however small and gentle, was given just before the patient was subjected to operation may be thought to remove this case from the group of spontaneous perforations, but taking into consideration all the relevant points I am confident that in fact the giving of the enema did not produce the perforation.

Five years later the patient is well and symptom-free.

Case 2.—Mrs. E. W., aged 49 years, was admitted on Jan. 2, 1956, complaining of severe lower abdominal pain of about twenty-four hours' duration. It had started in the early hours of Jan. 1, suddenly awakening her; and later she had vomited several times. The pain had become worse after she took a dose of castor oil about eight hours before admission. There was no history of dyspepsia but she had always suffered from constipation. She had had a subtotal hysterectomy twenty-three years previously and a partial thyroidectomy in 1949.

On Examination.—The patient looked acutely ill; her temperature was subnormal, her pulse rate 82 per minute, and respiratory rate 32 per minute. The tongue was furred. The abdomen moved but little with respiration; there was generalized abdominal tenderness and rigidity; no bowel-sounds were heard. Her blood-pressure was 135/80. Rectal examination revealed a hard mass, of doubtful nature, in the pouch of Douglas; there was no fæcal matter palpable in the rectum, but some blood was observed on the finger after the examination. The patient was thought to be suffering from acute peritonitis and therefore subjected to immediate operation.

At Operation.—When the abdomen was opened fæculent-free fluid was found and diffuse acute peritonitis. Very hard fæcal masses were present in the left colon, and near the rectosigmoid junction there was a vertical linear tear in the bowel, on its antimesenteric surface, through which some fæcal masses had escaped into the pelvis. There were numerous plaques of 'lymph' on the adjacent peritoneal surfaces but no sign of any lesion of more than about twenty-four hours' standing. The laceration was thought to be about 2½ in. long, running down into the upper part of the rectum; as it could not be exteriorized it was closed with interrupted sutures, and a proximal colostomy fashioned.

Progress.—Nasogastric suction, intravenous fluids, and antibiotics were the basis of treatment during the immediate post-operative period. After a few days the patient's condition began to improve and though wound sepsis and a residual pelvic abscess complicated the convalescence her progress was reasonably satisfactory. In due course the colostomy was closed, and when she was dismissed on April 4 the patient's wounds were healed, the bowels were moving regularly (with the help of Agarol), and a barium enema had been reported as showing a normal lower colon apart from possible adhesions in the pelvic segment.

COMMENT

Two cases of spontaneous perforation of undiseased pelvic colon are presented. Both occurred in middle-aged women who had had previous abdominal operations, but in neither were intraperitoneal adhesions considered to be unusually numerous. One admitted to suffering habitually from constipation and showed evidence of it at operation; the other did not. There was no proof in either case that the bowel had been penetrated from within by a foreign body. The only comparable case which has been recorded, so far as I am aware, is that described by Brown, but his patient was male, as were almost all the others whose records are to be found in the literature which deals with non-traumatic perforation of gut, though Eadie's (1955) and Lataix's (1949) patients were women and Quenu's account (1882) of spontaneous perforation of the rectum dealt with 6 female and only 1 male case. This last has probably been the source of the information, found in several papers, that prolapse of the rectum may be complicated by rupture of its anterior wall: "La rupture spontanée du rectum est un accident fort rare . . . qui n'a été observé que chez des adultes, et presque toujours chez des femmes (6 fois sur 7). Sur les cinq observations

complètes que nous possédons, le prolapsus du rectum est noté quatre fois, et il s'agissait de prolapsus anciens et très prononcés." In neither of the cases described here was there evidence of rectal prolapse, or of herniation of small intestine through the hole in the rectum, a phenomenon which occurred in several of Quenu's cases. More than one author has commented on what Aird (1949) calls the strange relationship between inguinal hernia and closed injuries of bowel, but this seems to refer almost exclusively to small bowel injuries, although in Wilensky and Kaufman's comprehensive review (1937) of 43 cases of what they called, in the title of their paper, subparietal rupture of the intestine due to muscular effort, there was 1 case of rupture of the sigmoid and 1 of the cæcum (or possibly colon). Even in these cases the authors seem to have regarded the associated inguinal herniæ as very significant causal factors (the subtitle of their paper is "A Complication of Hernia"). None of the Wilensky and Kaufman patients were females and in the two women here described no inguinal or other hernia was found. "Thus", as Huntley put it in summing up his case report, "no cause to explain the rupture can be assigned."

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CUTANEOUS HÆMATOMA SIMULATING MELANOMA

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IT is generally known that a wide variety of lesions may enter the differential diagnosis of malignant melanoma of the skin. If, after their consideration, the possibility of melanoma remains, it is necessary to act on the assumption that the lesion is a melanoma until proved otherwise by histological examination. The general consensus of opinion appears to be that the primary treatment should be a wide local resection, while some authorities also perform a block dissection of the regional lymph-nodes at the same time if they have no doubt about the diagnosis and the tumour is so placed that dissection in continuity can be performed. The risk of unnecessary major surgery based on a possibly erroneous clinical diagnosis prompts me to report a series of 5 cases of cutaneous or subungual hæmatoma. In 2 of them (*Cases* 1 and 4) the surgeons were confident that they were excising malignant melanomata. In *Case* 2 this was thought probable, but not certain. In *Case* 3 the patient, a young doctor, feared a melanoma although the surgeon who removed the lesion thought this unlikely. *Case* 5 was thought to have a melanoma until the surgeon had had the opportunity of discussing the previous cases, when he reconsidered the matter and decided that the lesion could be a hæmatoma.

CASE REPORTS

Case 1.—An athletic undergraduate, aged 20 years, discovered a deeply pigmented lesion on the back of his right heel in September, 1954. Previously he was unaware of any abnormality in this region and there was no specific history of trauma. During the following two months the lesion grew to three times its original size (*Fig.* 480). It was rounded, of dark-bluish colour, with two separate dark spots just outside the periphery. It was seen by several doctors, none of whom had any doubt that it was a melanoma. In view of the confident clinical diagnosis, pre-operative radiotherapy was given and on Dec. 1 Professor T. Pomfret Kilner performed a wide local excision. Professor Kilner wrote that it was suggested that he was going to be much too conservative in refusing to contemplate amputation of the leg.

FIG. 480.—*Case* 1. Clinical appearance of hæmatoma of heel.

The specimen (RISH 7638/54) was an almost circular portion of skin 6×5 cm. with subcutaneous tissue to a depth of 1 cm. Centrally there was a dark-bluish raised nodule 1·5×1 cm., just outside which were two small dark spots. On bisection the pigmented area appeared to be within the epithelium. Sections were taken through both the main pigmented area and the small spots, and all were of similar appearance. The keratinized layer of the epidermis was greatly thickened and lying in horizontal clefts within its substance were one large and a few smaller yellowish-brown sharply defined masses of amorphous material. These gave a strongly positive benzidine reaction for blood and negative staining reactions by the Prussian blue method for iron and Masson's silver

stain for melanin. The deeper part of the epidermis and the dermis showed no abnormality. The picture was that of an intra-epithelial hæmatoma.

Case 2.—A man, aged 43 years, fractured his left tibia and fibula in 1951 and his leg was in plaster for six months. In March, 1954, he sought the advice of Mr. P. H. Lenton about a dark spot which had developed on the outer side of the middle third of the left calf six months previously. During this time it had enlarged slowly and had been a little irritable and occasionally sore. A week or two before he was seen, a second smaller spot developed above the first. The lesions were slightly raised, firm, and almost black in colour, and one small

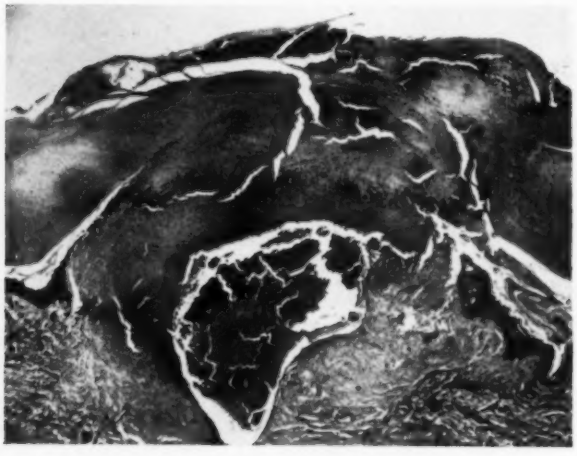

FIG. 481.—*Case* 2. Hæmatoma formation with crusting over ulcerated vein. (× 20.)

firm lymph-node was felt in the left groin. There was no history of trauma subsequent to the fracture, and an interval of some two years between the final removal of the plaster and the first appearance of the lesion. No varicose veins were evident. A melanoma was suspected and a wide excision biopsy was performed.

The specimen (RISH 1676/54) was a skin ellipse 5 × 2 cm., with subcutaneous tissue 1·5 cm. in thickness down to the deep fascia. Centrally there was a firm, raised pigmented nodule 0·7 cm. diameter, adjacent to which was a second slightly elevated pigmented lesion 0·5 cm. in diameter. Sections of the larger lesion showed a vein extending up to an area of ulceration of epidermis (*Fig.* 481). The wall of the vein was eroded and a crust covered the epidermis, with areas of yellowish-brown amorphous material extending laterally in the keratinized layer. In the smaller lesion was another area of this amorphous material, which gave a positive benzidine but a negative Prussian blue reaction.

Case 3.—A doctor, aged 28 years, was anxious about a small black nodule which he had noticed for two weeks in the previously normal skin of a finger. He could remember no related injury, and in view of the patient's concern that it might be a melanoma, it was excised by Mr. A. Elliot Smith.

The specimen (RISH 8013/54) was a circle of skin 0·7 cm. diameter with a central black spot 0·2 cm. in diameter. It was a localized hæmatoma in the keratinized layer of the epidermis (*Fig.* 482) bounded by a zone of parakeratotic cells and giving a positive benzidine reaction.

Case 4.—A woman, aged 62 years, was seen in October, 1951, on account of a stiff shoulder. It was seen that she had a black nodule 1 cm. in diameter on the left arm. The surface was smooth, the edges well defined, and the base indurated. She had first noticed it thirty years before and for five years it had been enlarging, but it had caused her no concern. No axillary lymph-nodes were palpable. A wide local excision was performed by Mr. D. A. Abernethy, and the lesion was found to be a malignant melanoma (RISH 5899/51). Seven weeks later a block dissection of the left axilla was performed and histological examination revealed no metastases. She attended again in February, 1955, with a raised, almost black, rounded lesion 0·3 cm. in diameter on the left wrist. This she had first noticed as a tiny black speck in the skin a year previously and it had enlarged with increasing speed. In view of the history this was confidently thought to be a recurrence of the melanoma

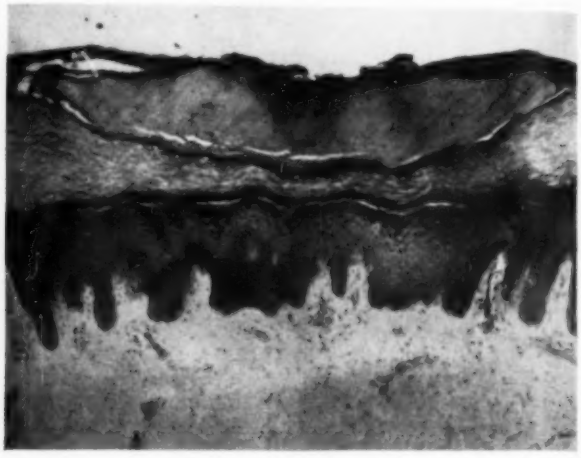

FIG. 482.—*Case* 3. Hæmatoma in superficial part of keratinized layer. (× 22·5.)

and widely excised. The specimen (RISH 969/55) showed only an old intra-epithelial hæmatoma. There was some perivascular lymphocytic infiltration in the superficial dermis.

Case 5.—In March, 1956, a woman, aged 65 years, was seen by Mr. D. C. Corry on account of a black patch beneath a finger-nail. This first appeared four years previously and she remembered no related injury. When it had been present for about a year she showed it to her doctor and was told that it would disappear. Instead it persisted and enlarged. Although suspecting a melanoma, Mr. Corry was reluctant to perform an unnecessary amputation of the digit and equally to take a biopsy of a probably malignant tumour. After discussion of the previous cases, he inclined to the view that this also might well be a hæmatoma and avulsed the nail.

The specimen (RISH 1608/56) was a finger-nail with an adherent patch of black material 0·7 × 0·4 cm. on the posterior surface, reaching to 0·2 cm. from the distal margin. On section, it was an old subungual hæmatoma.

DISCUSSION

Beerman, Lane, and Shaffer (1955), in their excellent review of the recent literature of pigmented nævi and malignant melanoma of the skin, give an impressive list of differential diagnoses of malignant melanoma. This includes the pigmented nævus, sebaceous wart, granuloma pyogenicum, pigmented basal-cell carcinoma, histiocytoma, and blue nævus. Less frequently, confusion occurs with verruca vulgaris, fibroma, sebaceous cyst, kerato-acanthoma, glomus tumour, or Kaposi's sarcoma. They also refer to the paper by Goldman (1947), the only

previous publication that I have discovered on cutaneous and subcutaneous hæmorrhage simulating melanoma. Goldman describes 5 cases. In one a tender bluish spot developed, without preceding injury, on the sole of the foot of a man aged 52 years. It gradually increased in size and colour. The patient's physician suspected a melanoma, but transparency testing with xylol and intense illumination resulted in a correct pre-operative diagnosis of a callus with old hæmorrhage. A second patient had a similar lesion on the ankle. In the third and fourth, a halo of hæmorrhage developed around epidermoid cysts of the forehead, and in the fifth hæmorrhage arose around the scar of a previously excised malignant melanoma and was thought to be a local recurrence.

A large proportion of cutaneous lesions which at first glance could be melanomata are excluded on the basis of history and careful examination. Previous trauma will suggest the possibility of a hæmatoma, but it is remarkable how often a patient with a melanoma will date its appearance from an injury. This applies more particularly, but not exclusively, to cases where malignancy arises in pigmented nævi. In all of the cases in the present series the lesion occurred in apparently normal skin. This was true in 3 of Goldman's cases. In one, the patient thought he had had a birthmark at the site, although this was not confirmed histologically; and in the fifth a melanoma had already been excised. Enlargement of benign nævi may be the result of infection or many other causes, such as the development of a sebaceous cyst deep to the nævus. In none of the present cases was there any history of trauma, although in *Case* 1 the heel of an athletic young man is obviously a vulnerable site. One of Goldman's patients admitted to squeezing the small epidermoid cyst on her forehead. The proportion of melanomata with no history of a preceding mole is variously stated as from 37 per cent (Clarke, 1952) to 75 per cent (Becker, 1954).

The features in common in the present cases which contributed most to the suspicion of melanoma were the length of history and the apparent growth of the lesion. In *Case* 5 the subungual hæmatoma persisted for four years. During this period a fingernail normally grows about 6 in. (Le Gros Clark, 1939) and it is usual for the hæmatoma to ascend with the nail and be shed. Nothing was seen to account for the unusual behaviour in this instance. In *Case* 3 the history was only short, but the anxiety of the patient was understandable. In the remaining cases the enlargement of the lesion without any loss of pigmentation was striking. It is presumably explained by spreading and thinning out of the hæmorrhage in the deeper part of the keratinized layer. More deeply situated collections of blood would be expected to undergo the normal process of removal.

Becker (1954) recommends that the minimum initial treatment of suspected melanomata should be excision biopsy, although he could find no reports of dissemination by partial biopsy. For the more highly suspicious lesions he recommends immediate wide local excision. Because of the relative inaccuracy of clinical diagnosis, he deprecates destructive and mutilating surgery without histopathological confirmation after local excision. This line of approach appears to be a majority opinion in the recent literature, and is similar to that of Cunningham (1952), but some insist that the initial procedure after clinical diagnosis should be wide local excision. For example, Clarke (1952) stipulates that the primary excision should have a margin of 2 in. of normal skin and that its depth should include the deep fascia. Few would now amputate more than a digit without confirmation of the diagnosis, but the advisability of so doing was seriously considered in the first case here reported.

The difficulty of clinical diagnosis at an early stage is confirmed by a study of the records of the Pathology Department of the Radcliffe Infirmary. Of the last 50 specimens received with a confident clinical diagnosis of malignant melanoma, this was correct in 42. Of the last 50 suspicious pigmented lesions, including enlarging moles, removed in case they were melanomata, evidence of malignancy was found in only 10. The practice here is for a minimum of excision biopsy, the width of clearance depending on the degree of suspicion, but if wide excision had been performed in all cases the degree of unnecessary mutilation would have been considerable. If cutaneous hæmatoma is included among the possible alternative diagnoses even when the history is atypical, an accurate pre-operative diagnosis may sometimes be reached by procedures such as the transparency test described by Goldman (1942) for the differential diagnosis of plantar warts. He recommends the application of alcohol, xylol, or oil to make the keratinized surface transparent, followed by examination under a strong light, held to one side to produce lateral transillumination. This procedure should often suffice to show whether the pigmented area is in or deep to the keratinized layer.

SUMMARY

Five patients are reported in whom lesions clinically thought to be melanomata were revealed by histology to be cutaneous or subungual hæmatomata. There was no clear history of previous trauma, and the lesions in 4 cases persisted over abnormally long periods and appeared to grow.

It is a pleasure to thank the surgeons who have allowed me to report these cases, and Professor Kilner additionally for permission to use his clinical photograph of the first case.

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NASOPHARYNGEAL CANCER: A PROBLEM IN DIAGNOSIS

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Despite steady improvement in our methods of treating cancer, it is widely recognized that our main hope of bettering the cure rate, at least in the immediate future, is by earlier diagnosis. Malignant tumours of the nasopharynx offer a striking challenge in this respect for a very long delay in establishing the diagnosis is almost the rule. Nor is the ready excuse that it is our patients who are to be blamed valid on this occasion, for McWhirter (1953) has told us that the delay (of 9·5 months, on the average, in his series) was, in most cases, mainly attributable to the medical attendant.

For this delay there are, or so it seems to us, a variety of very good reasons :—

1. Nasopharyngeal cancer is almost a rarity in the western world. Thus, although it remains a highly fatal disease, deaths from this cause in the returns of the Registrar General for England and Wales (population, 44 millions) in 1953 numbered only 100. For comparison, there were in the same period 8239 deaths from cancer of the breast and 14,253 from cancer of the stomach.

In the experience of the large Christie Hospital and Holt Radium Institute in Manchester, which must select material from a very wide area of the midlands of England, only 100 patients (carcinoma 65, sarcoma 35) were treated between 1932 and 1950. (Lambert, 1954.) Godtfredsen (1946), who has written an exhaustive and authoritative treatise on this form of cancer, collected only 454 cases in ten years, from a population of 7·5 millions in the Scandinavian countries, and on the basis of the study estimated a yearly incidence there of 1 case in approximately 180,000.

From these figures, it will be clear that no single consultant is likely to have any considerable experience in its management, and for most practitioners the chance of encountering even a single case, in a lifetime of practice, will be remote (McWhirter, 1953).

2. The clinical features are so widely variable that, even when a patient comes to hospital, he may find his way first to an otolaryngologist, an ophthalmologist, a neurologist, or even to a dentist. Experience shows that, all too often, they share with the general surgeon or physician the humiliation, for long, of overlooking the diagnosis. The only specialist who seems likely to see most of the cases is the radiotherapist, and by the time the patients find their way to him the diagnosis is usually all too obvious.

3. Even when the diagnosis of nasopharyngeal cancer is borne in mind, there are certain features of the anatomy and pathology of these tumours which together often make it exceedingly difficult to clinch the diagnosis. These features we propose to consider at length below.

A good deal has been written on this subject within recent years, and our only excuse for writing this further paper is, first, that we believe the diagnosis to be in many cases a matter of the very greatest difficulty, and, secondly, that there is still among general surgeons and physicians a regrettable lack of awareness of the varying clinical picture in such cases.

We have collected the records of 30 patients from the files of our hospital and from them we propose to draw clinical material to illustrate and underline our argument. It is significant to note that the average period which elapsed, in the 28 patients where the information was available, between the first symptom and the establishment of the diagnosis was 13 months. Five patients had symptoms for more than 2 years, and 13 for more than 1 year.

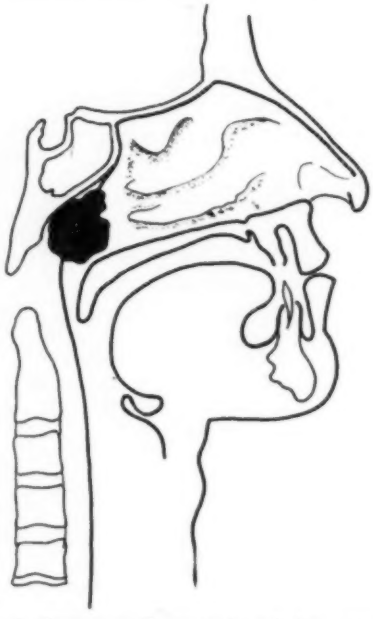


Fig. 483.—A diagram to illustrate the relative inaccessibility of a nasopharyngeal cancer.

ANATOMY

Anatomically the nasopharynx is remote and inaccessible (*Fig.* 483). It is situated behind the nasal cavity and at a considerable depth. Above is the base of the middle fossa of the skull, with the sphenoidal air sinus medially, flanked on each side by the cavernous sinus. Embedded in the outer wall of the sinus are the motor nerves of the eye (3rd, 4th, and 6th) and only a very little further laterally lies the ganglion of the trigeminal (5th) nerve and its motor and sensory roots. All of these structures lie very close to the roof of the nasopharynx and are often involved by the upward extension of tumour into the cranium (*Fig.* 484).

Running forwards in a bony canal in the floor of the sphenoidal sinus is the nerve of the pterygoid canal (nerve of Vidian) which conveys parasympathetic secretory fibres from the superior salivary

nucleus of the facial (7th) nerve to the lacrimal gland.

As the roof is followed backwards, it curves down to form the posterior wall, and here it is related to the basilar part of the occipital bone and the anterior arch of the atlas.

Below it communicates with the oropharynx through a narrow isthmus screened from in front by the sloping soft palate, and jealously guarded by a vigorous reflex which induces protective contraction

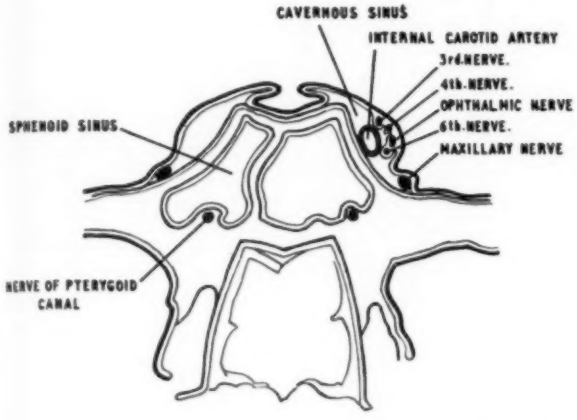


FIG. 484.—A coronal section through the posterior portion of the nasopharynx, to show its close relationship to the cranial nerves running forwards in the base of the skull. (*After Jamieson.*)

of the muscles in its wall and effectively closes the opening between the mouth and the nose, not only during speech and swallowing, but more important still, during attempts at examination of the space.

On the lateral wall is the opening of the pharyngo-tympanic (Eustachian) tube, and the upper encircling fibres of the superior constrictor. More laterally still are the pterygoid muscles, the great vessels, and the glossopharyngeal (9th) and vagus (10th) and spinal accessory (12th) nerves immediately below the jugular foramen.

PATHOLOGY

Any detailed discussion of the histopathology of malignant neoplasms of the nasopharynx is outside the scope of this communication. Suffice it to say that these tumours are often so anaplastic that classification is difficult and the separation of sarcoma from carcinoma a matter of opinion.

1. Primary Tumour.—There is, however, one very important point in their pathology which goes a long way to explain the great difficulties in diagnosis. Often the primary tumour is exceedingly small and is represented only by a scarcely perceptible and non-ulcerated elevation of the mucosa; this may be the case even when there are extensive regional lymph-node and even distant metastases. Even a painstaking pathologist may fail to spot it, for it is a part of the body which is difficult to display other than by a dissection which is more mutilating than permission for autopsy will often allow; little wonder then that such a small tumour in such an inaccessible site is not infrequently missed by the clinician. It is now widely believed that the diagnosis of 'branchial carcinoma' most often follows only the failure to detect a primary, and, of over-looked primaries, cancers of the nasopharynx must surely take pride of place.

2. Spread by Lymphatics.—Early dissemination to the regional lymph-nodes is another prominent feature of this neoplasm: it is often not only early but widespread and bilateral.

The nodes first affected are no doubt those which lie close up against the posterior and lateral wall of the pharynx, deep to the mandible and in the substance of the parotid gland. Lymph-node involvement is, however, seldom detected clinically until there is enlargement of the nodes of the cervical chain, and more especially of those which lie deep to sternomastoid, posterior and lateral to the upper part of the jugular vein, and spilling out behind the posterior margin of the muscle to lie in the closest relation to the spinal accessory nerve as it begins its course across the posterior triangle of the neck. Although selective involvement of this particular group of glands is not observed in every case, we believe that the detection clinically of any enlargement of these lymph-nodes, especially if bilateral, should immediately bring to mind in diagnosis nasopharyngeal cancer.

3. Spread by Blood-stream.—Later there will be widespread dissemination by the blood-stream, and this is especially a feature of the natural history of the disease when the primary has been effectively controlled by radiotherapy.

4. Local Spread.—Many of the striking clinical features of this form of cancer are due to local extension of the tumour to involve the base of the skull and the other adjoining structures, most important of which are the cranial nerves.

Often there is little evidence, at least radiologically, of destruction of bone, and the extension is in such cases mainly through the basal foramina such as the foramen lacerum. Once inside the skull, the tough dura of the base seems, for a time, effectively to protect the cerebrum, but the tumour spreads diffusely in the extradural space. In the advanced cases the entire base of the skull, including the medial parts of the middle and posterior cranial fossæ, may be completely destroyed and the tumour may invade the orbit, displacing the globe of the eye forwards. There will be a correspondingly wide extension in the soft tissues immediately below the base of the skull, often to fill the infratemporal fossa and later to erupt upwards under the temporalis muscle and present as a tumour of the temple.

The clinical features are widely variable, depending on the direction of the local spread; these will be considered shortly below.

AETIOLOGY

Before we proceed to a fuller discussion of the symptoms and signs, it is perhaps not out of place to mention briefly some points about the aetiology of this form of cancer.

Age.—Our cases fall within the range of 25 to 82 years: rather more than half of them were in their 50's or 60's.

Sex.—As is the case with most forms of cancer of the upper parts of the respiratory and alimentary tracts, there is a significant male sex preponderance. Of our cases 20 were men and 10 women, and this

sex distribution seems to correspond with that given in most of the larger series.

Racial.—Although it is not strictly germane to our discussion, since no Orientals are represented among our cases, it is perhaps allowable to point out that there is a quite astonishingly high incidence of this form of cancer in the Orient. This is especially the case among the Chinese (as studied, for example, in Hong Kong and Singapore) and also in the Malays, Indonesians, and Indians. This curiously racial predisposition to nasopharyngeal cancer is seen even among Chinese born and reared in metropolitan New York.

CLINICAL MANIFESTATIONS

The initial features are widely variable and the pattern of the illness may be quite different in one patient from the next. However, we can conveniently discuss the symptoms and signs under: (1) Those attributable to the primary tumour which may sometimes be large enough to block the nasopharynx and/or the pharyngo-tympanic (Eustachian) tube; (2) Those which result from direct extension of the tumour outside the nasopharynx; (3) Those which result from metastases to the regional lymph-nodes.

1. Symptoms due to the Primary Tumour.—The initial symptoms were of this nature in 2 cases out of every 3, and in the majority it was the obstructive rather than the destructive features of the tumour which were most evident. Five had nasal obstruction as the first symptom and 8 came complaining of deafness: 1 other had tinnitus and pain in the ear from the very beginning. Four others were troubled by nasal discharge, mucoid or semi-purulent, and often blood-stained.

These symptoms are such a commonplace in the run of general practice that it is in no way surprising to find that only a symptomatic diagnosis was made at the outset and valuable months were lost in the use of drops, irrigations, inhalations, and the like. Eventually such patients find their way to the out-patient clinic of the otolaryngologist, but often only after some new and urgent happening has presented. The anterior extension of a nasopharyngeal cancer was on several occasions removed in the belief that it was a nasal polyp, assumed benign and not sent for section.

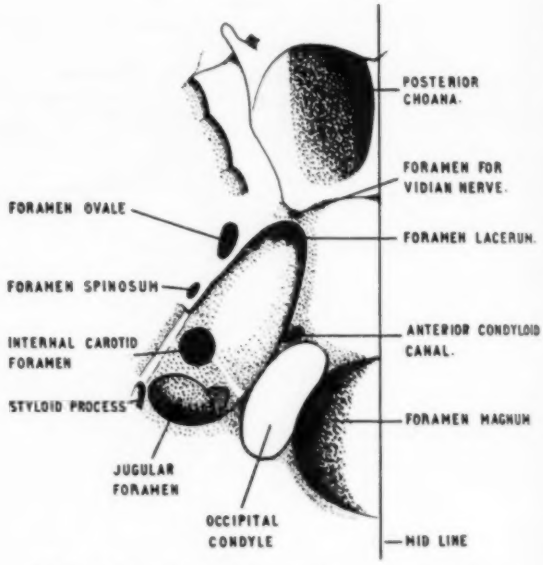
One patient, a man of 61, had frontal headache and bouts of epistaxis and was for long treated as a case of hypertension. When he eventually found his way to hospital, there was a very large nasopharyngeal tumour effectively blocking both nostrils.

2. Symptoms due to Extension Outside the Nasopharynx.—In 7 out of 23 cases in which a detailed neurological examination had been recorded there was already evidence of nerve involvement, and 7 others developed signs later in the disease. The incidence in the advanced cases may be as high as 70 per cent.

Because of their situation so close to the roof of the nasopharynx, it is the motor nerves of the eye which are most often first affected.

One of our patients, a man of 56, had, when first seen, a left ptosis, and a small pupil on that side. There was also atrophy of the left half of the tongue. He also admitted a history of pain in the left ear. The nasopharynx was carefully examined with negative results and X-ray studies were likewise fruitless. The symptoms were attributed to some form of degenerative nerve disease. One month later he developed bilateral lymph-node metastases confirmed by biopsy, and died of widespread disease without the exact site of the primary having been established.

The abducent nerve is especially vulnerable and diplopia and a convergent squint is a common finding. Patients with such cranial nerve palsies usually come



Right half of basis cranii forming the roof of nasopharynx.

FIG. 485.—Diagram illustrating how the lateral extension of a tumour on the roof of the nasopharynx comes to implicate the cranial foramina at the base of the skull.

under the care of the ophthalmologist or of the neurologist and are often diagnosed in the first instance as cases of cerebral tumour or of disseminated sclerosis. Two of our patients first reported sick with pain in the distribution of the maxillary division of the trigeminal. Repeated examination of the nasopharynx was in both for a long time negative, but in one there was eventually radiological evidence of extensive destruction of the base of the skull. One of the most important symptoms of nasopharyngeal cancer is obscure pain in the face. (Gooddy, 1953.) Trigeminal neuralgia is always a dangerous final diagnosis unless a very diligent search has been made for its cause: anæsthesia in the distribution of the nerve in such cases is a most significant finding.

Patients with pain referred to the upper jaw and teeth often consult their dentist, and a history of repeated and useless extraction of healthy teeth is all too frequently elicited (New, 1922).

Although the 6th and 5th cranial nerves are most often affected, and the 3rd and 4th rather less so, almost any of the others may be implicated (*Fig.* 485). The cervical sympathetic, too, may be implicated, and the various combinations of symptoms and signs which may be recognized clinically have come to be known by the names of the authors who first described them.

Trotter (1911) more than forty years ago drew attention to the combination, in some cases, of neuralgic pain in the face and temple along with paralysis of the soft palate (from direct involvement of the levator palati) and ipsilateral deafness of the air-conduction type, all resulting from the lateral and upward extension of a tumour on the lateral wall of the nasopharynx.

was clinical evidence of extension to the cervical nodes when the patient eventually found his way to hospital. In one or two the diagnosis was speedily arrived at, but all too often far too much attention seemed from the very outset to have been paid to the neck swelling, which was forthwith removed surgically. It was only on receipt of the pathologist's report that it was a node containing deposits

A B

FIG. 486.—Photographs to show the characteristic position of the cervical lymph-node enlargement in nasopharyngea cancer. In this patient (male aged 67 years) both sides were affected, as was a small parotid node.

Jacod's triad of amaurosis, trigeminal neuralgia, and ophthalmoplegia implies extensive involvement of the most medial part of the fossa, and Gradenigo's syndrome points to a lesion rather more posteriorly with the extension into the apex of the petrous temporal bone, with abducent paralysis and pain in the temple. Wilson (1954) has recently drawn attention to the significance of excessive lacrimal secretion from irritation of the nerve of the pterygoid canal, which often goes hand in hand with an insensitive cornea from paralysis of the ophthalmic division of the 5th. (*See also* Flatman, 1954.)

There seems, however, little merit in trying to group cases together in this way. It is important to remember how bizarre the combination of nerves involved may be, as is strikingly illustrated in the paper of Digby, Fook, and Che (1941). This alone, especially when the condition is rapidly progressive, should suggest the diagnosis of nasopharyngeal cancer as a strong possibility.

3. **Symptoms of Metastases to Regional Lymph-nodes.**—Seven of our 30 cases had a "lump in the neck" as the first manifestation of their disease, and in no less than 22 of them there

of an epidermoid carcinoma (commonly anaplastic) that a diligent search was made for a primary lesion in the nasopharynx or elsewhere.

This mistake is perhaps understandable in a young person when a diagnosis of tuberculosis or of a malignant reticulosis may first suggest itself. A meticulous investigation of the upper air and respiratory passages must, however, be regarded as an essential part of the examination of such a patient, whether young or old.

There are certain features of the lymph-node enlargement in such cases to which we would like to direct attention.

a. Their Position.—If one omits the enlarged suboccipital and mastoid lymph-nodes which may be found in children infested with head lice, the cervical nodes which are most often enlarged (and this is, in general, true whether the cause is infective or neoplastic) are those which we often call 'tonsillar' and which lie in the anterior triangle of the neck and in close relationship to the posterior belly of the digastric and the common facial vein. These nodes lie anterior to the sternomastoid muscle and at a level just above the half-way point between the mastoid process and the clavicle.

Metastatic nodes from a primary in the nasopharynx are characteristically higher up and most posteriorly (*Fig.* 486). The nodes belong to the upper component of the jugular chain and they extend backwards deep to the sternomastoid into the posterior triangle. Although it is admitted that these same nodes may be primarily affected in tuberculosis the tonsillar gland is under these circumstances seldom spared. We believe that in the finding of enlarged neck nodes, which are situated *high up and far back*, it is proper first to exclude a cancer in the nasopharynx: this would especially be the case when the nodes are enlarged on each side.

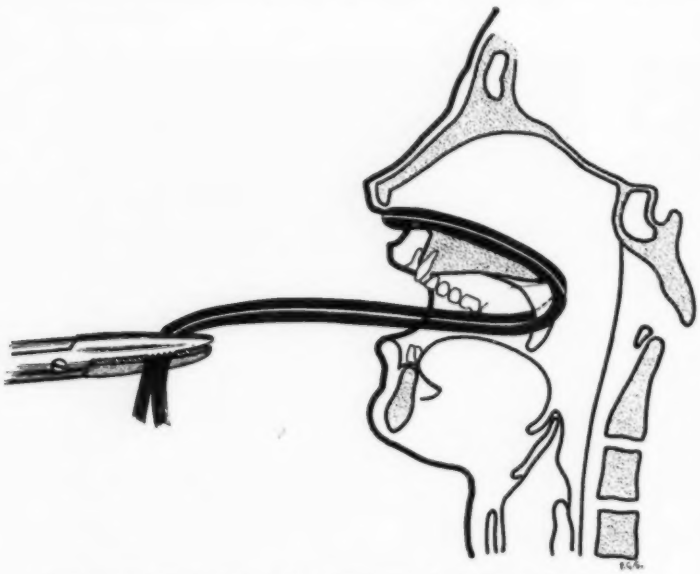


FIG. 487.—Examination of the nasopharynx is facilitated by traction on both ends of a rubber catheter threaded through the nose.

b. Their Consistency.—The nodes are seldom so hard as they are when metastatic to an epidermoid mouth cancer, and they are often inordinately large. If the nodes are very large and direct questioning gives no hint of the presence of a primary in the mouth or throat, a malignant lymphoma or a nasopharyngeal cancer seems most likely: large tuberculous nodes almost always break down with resulting fixation and abscess formation.

c. Their Relative Size.—Digby and others (1941) have pointed out that the enlargement of the lymph-nodes is almost always more advanced on one side than on the other—it is "asymmetrical and asynchronous". They regard this as a point of much diagnostic value.

DIAGNOSIS

The anterior nares give the clinician ready access only to the vestibule: with his lamp and mirror he can examine the turbinates and the septum. For the illumination and visualization of the nasopharynx an instrument must be passed backwards beyond the choanæ. Although a variety of endoscopes has been devised, none seems to have been entirely satisfactory and we have no experience in their use.

The alternative is to approach the nasopharynx through the mouth. In an advanced case the lower edge of a tumour may be seen presenting below the lower edge of the soft palate or extending to an even lower level by direct spread into the posterior wall of the oropharynx. More often, however, it will be seen only indirectly by mirror examination. The nasopharyngeal isthmus is small even when the patient breathes quietly through the nose: it will at the best of times allow the use of only a small mirror with resulting indifferent illumination and a restricted visual field. It is exceedingly difficult to examine every nook and cranny. This is a method of physical examination which requires much patience and manual dexterity and even when a good view is obtained, the interpretation of what is seen comes only after considerable experience. Moreover, it often demands of the patient a degree of co-operation which many find it difficult to afford. Mirror examination can be facilitated in two ways: First, a self-retaining spring soft-palate retractor may be inserted after spraying the throat and palate with a surface anæsthetic. The retractor can be steadied by an assistant and then a more thorough and unhurried mirror examination carried out. A much better method in our hands is that practised in difficult cases by Dr. Hayes Martin in the Memorial Hospital, New York. After anæsthetizing the nose and throat, one end of a fine rubber catheter (urethral) is threaded through each nostril and delivered into the mouth, the loop of the catheter being drawn up against the columella of the nose. Traction on the ends of the catheter facilitates examination remarkably by pulling forwards the soft palate. This we can recommend as a most valuable manœuvre: it makes all the difference to the visualization of the nasopharynx, but it implies a good deal of patience on the part of the examiner (*Fig.* 487).

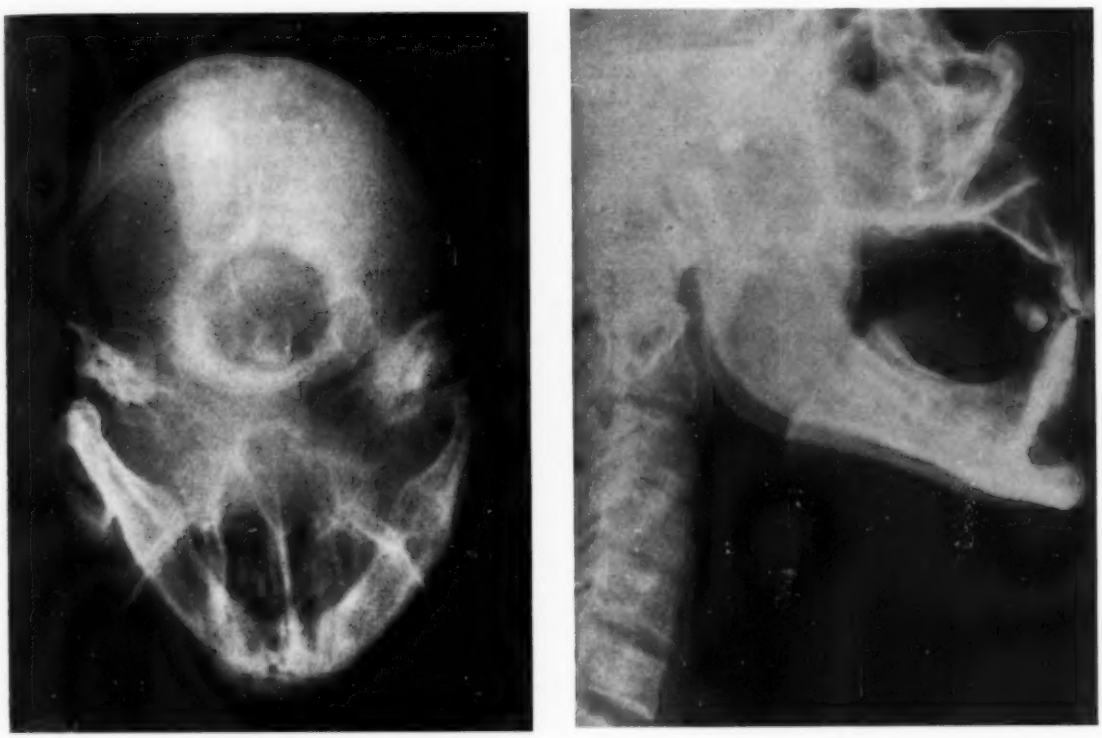
The narrowness and depth of the inferior aperture of the nasopharynx makes even palpation of the space difficult and extremely uncomfortable both for the patient and the examiner. Although one can sometimes feel a tumour through the soft palate, it is virtually impossible to insinuate the finger around and behind the soft palate and to feel the lateral and posterior walls with the pulp of the finger. Anæsthetizing the patient is a help, but even then, probably only fairly large and protuberant tumours could be felt by palpation.

If bleeding is initiated by a gentle and easy examination, the presence of a tumour is highly likely.

The detection by mirror examination of any suspicious area should be followed by its biopsy, taken by a pair of straight forceps passed along the floor of the nose.

We have in a few cases found blind biopsy a valuable diagnostic manœuvre. The forceps (passed through the nose) explores the side of the nose to which the symptoms direct, and representative fragments of the mucous lining are taken for section. When a tumour is present, a large portion of tissue is obtained with the greatest of ease and usually to the accompaniment of some brisk hæmorrhage. The procedure seems, however, to be a safe one.

Wilson (1951) talks of splitting the soft palate in the midline to facilitate access to the nasopharynx and of then removing a slice of tissue blindly from immediately behind the Eustachian tube and going down to the prevertebral fascia.



A B

FIG. 488.—A, B, Basal and lateral views of skull showing extensive bone destruction and a large associated soft-tissue shadow. The patient was a man aged 48 years with a large nasopharyngeal tumour, but who had complained of nasal obstruction for only four months.

Soft-tissue radiography is an auxiliary method of diagnosis which is used all too seldom (*Fig.* 488). The radiological evidence of destruction of the base of the skull is a late feature of the disease : a negative film is of no value whatsoever in the exclusion of nasopharyngeal cancer.

It will be admitted that when the symptoms and signs point clearly to the presence of a tumour in the nasopharynx the primary still eludes. This is equally true when a biopsy of the regional nodes shows them to contain tumour. Under such circumstances the nasopharynx will be examined again and again and with the greatest care and patience. After repeated negative explorations, the patient is then usually treated by radiation : and the site of the primary may never be established. However, as repeated and assiduous search for nasopharyngeal tumours continues, so the number of cases in any clinic indexed as ' branchial carcinoma ' will fall proportionately.

SUMMARY

Cancer of the nasopharynx is often overlooked. For this there are several good reasons, among them being its infrequent occurrence, its relative inaccessibility, and some peculiarities of its pathological behaviour. The mode of clinical presentation is varied. The patients may come first to the surgeon with a lump in the neck, to the otolaryngologist with nasal obstruction or deafness, to the physician with trigeminal neuralgia, or to the ophthalmologist with diplopia and a squint. The initial symptoms are often trivial. There are often, however, certain clinical features which should suggest the correct diagnosis, and to these we have drawn attention.

Our thanks are due to our colleagues who have afforded access to the records of the patients under their care, and especially to Dr. C. Wood, Director of the M.R.C. Radiotherapy Research Unit at Hammersmith Hospital. The illustrations are the work of the Department of Medical Illustration in the Postgraduate Medical School of London.

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MARCH HÆMOGLOBINURIA

A REPORT ON TWO CASES

By J. CHALMERS

FROM THE ROYAL NATIONAL ORTHOPÆDIC HOSPITAL

MARCH hæmoglobinuria is a condition affecting males between the ages of 16 and 35 years. It is characterized by hæmoglobinæmia and hæmoglobinuria following exertion.

In 77 of the 80 recorded cases the attacks have been induced by exercise in the erect position. It is a benign disease, spontaneous resolution occurring within a few months or years of onset. It is not associated with any other abnormality, although an increased lumbar lordosis has been occasionally observed. It gives rise to no distressing symptoms other than dull pains in knees and thighs which have been present in a few cases.

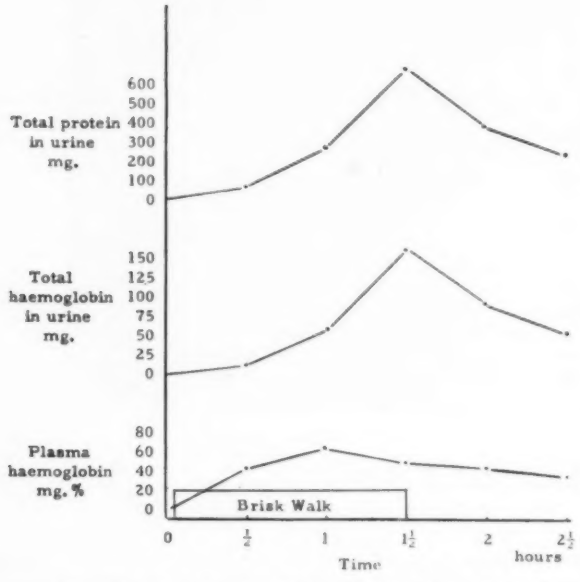

FIG. 489.—*Case* 1. Graphs showing the effect of a brisk walk on urinary protein, urinary hæmoglobin, and plasma hæmoglobin.

In view of the comparative rarity of the condition the following cases are presented.

CASE REPORTS

Case 1.—A private soldier, aged 18 years 10 months, was admitted to hospital on Aug. 20, 1952. He complained of passing dark-red urine on about nine occasions during the previous two months. He was unable to relate the episodes to any antecedent circumstances. The attacks were not associated with any dysuria or other symptoms. During this period he had experienced frontal headaches usually in the morning and not coincident with the discoloration of the urine. Since 12 years of age he experienced inconstant pains in arms, legs, and lumbar region. These pains were not severe enough to interfere with his normal activities, but he was discharged from Boy Service in the Navy three years previously on their account. A report from the Naval Hospital in which he was investigated at that time states that no abnormal findings were found then on physical examination, the urine also showed no abnormality. These pains persisted to the time of writing, but did not appear to be related to his urinary pigmentation. Otherwise he was well and able to carry out his full duties as a soldier.

Family history was non-contributory.

The patient looked fit and well built, with good posture. Height 72 in. Weight 152 lb. Physical examination revealed no abnormality. There was no enlargement of liver or spleen. B.P. 120/80. Urine was straw coloured and contained no pathological constituent

During three weeks in hospital he passed dark-red urine on nine occasions, always following exertion in the erect position. The colour was found on spectroscopic examination to be due to hæmoglobin. Very occasional red blood-corpuscles were present. A marked proteinuria occurred simultaneously with the hæmoglobinuria.

The hæmoglobinuria persisted for 2-5 hours after the exercise. A walk of 2 miles was sufficient to precipitate an attack. Between attacks the urine was always found to be normal in all respects. Exercise in other positions, e.g. cycling and swimming, failed to produce hæmoglobinuria. Hæmatological examination was normal and the following were all negative: W.R., Kahn, Coombs' test, Donath Landsteiner reaction, Cold immersion (Rosenbach's test). Intravenous pyelogram showed no abnormality.

Fig. 489 shows the changes which took place in the plasma-hæmoglobin, urinary hæmoglobin, plasma-bilirubin, and urinary protein during and following a brisk walk. At half an hour the plasma-hæmoglobin was 40 mg. per cent and the urine hæmoglobin 17 mg., showing that the renal threshold was below 40 mg. per cent. It can also be calculated that the amount of blood hæmolysed was in the order of 15 ml. The absolute amount of protein and hæmoglobin in the urine were closely parallel.

Injection of 0·5 c.c. of adrenaline subcutaneously failed to produce hæmoglobinuria. Fasting for 12 hours prior to exercise failed to prevent hæmoglobinuria.

Since November, 1953, he has had no further episodes of hæmoglobinuria despite playing rugby and football regularly, and has remained in perfect health.

Case 2.—A private soldier, aged 20 years, was admitted to hospital on April 16, 1953. He was a keen athlete and a cross-country runner of above average ability. On two occasions during the previous five months following cross-country runs he had noticed that his urine was red coloured. The urinary pigmentation was not associated with any pains or other symptoms. He had had no previous illness.

On examination the patient appeared robustly healthy, with excellent physique and good posture. Height 64 in. Weight 146 lb. No abnormality was found on physical examination. B.P. 125/80. Urine was entirely normal. Hæmatological examination was normal. W.R., Kahn, Coombs' test, and Donath Landsteiner reaction were all negative.

Blood and urine were examined before and after a 3½-mile run on several occasions, and consistently showed a rise in serum-hæmoglobin with hæmoglobinuria and proteinuria following the exercise.

A typical result was :—

Before Exercise		*After Exercise*	
Serum Hb	nil	Serum Hb	0·14 g. per cent
Urine Hb	nil	Urine Hb	3·3 g. per cent
Urine protein	nil	Urine protein	++
Urine deposit	nil	Urine deposit : scanty granular casts and amorphous debris	

The test was repeated after 12 hours' starvation. The serum-hæmoglobin rose to 0·22 g. per cent, but there was no hæmoglobinuria although a proteinuria of 0·25 g. per cent occurred.

Four months later he was re-admitted. He had noticed hæmoglobinuria on only one further occasion after a game of tennis lasting three hours. A 9-mile run produced the typical blood and urinary changes, showing the condition to be still present.

DISCUSSION

The chief clinical importance of march hæmoglobinuria rests in its differential diagnosis from the other more serious causes of paroxysmal hæmoglobinuria or hæmaturia. (It seems probable that most cases will be referred, as were these two, to the surgeon as cases of hæmaturia.) The establishment of a definite relationship to exercise and normal urinary findings at the time of examination are sufficient for diagnosis and will spare the patient a full urinary investigation.

The aetiology of the condition remains obscure.

The fact that attacks are produced by exertion in the erect position suggests an analogy with orthostatic albuminuria, but Schellong (1923) demonstrated that in march hæmoglobinuria the hæmoglobin and protein come from both kidneys, whereas in the latter condition the protein comes only from the left kidney.

Lubran and Sakula (1949) point out that splenic blood undergoes spontaneous hæmolysis *in vitro*, and postulate a contraction of the spleen produced by the stimulus of exercise in the erect position, discharging a quantity of fragile red cells into the circulation. Injection of adrenaline in *Case* 1 and in the cases of Porges and Strisower (1914) and Lang and Braun (1931) failed to cause hæmoglobinuria.

Bell (1947) found that in his case hæmoglobinuria was only produced by exercise shortly after a meal. This was observed in *Case* 2, but not in *Case* 1 of this report.

Gilligan, Alteschule, and Katersky (1941, 1943) found that 18 out of 22 marathon runners had elevated plasma-hæmoglobin levels after a 26-mile run—average 14 mg. (100 ml.)—and in 4 there was a slight hæmoglobinuria.

These authors also found that the normal renal threshold for hæmoglobin is 100 mg./100 ml. of blood. In march hæmoglobinuria the threshold is lowered to under 40 mg./100 ml., which is confirmed in *Case* 1.

McDonald, Miller, and Roach (1951) have demonstrated that there is a high glomerular permeability to hæmoglobin (12·9 per cent of the glomerular permeability to inulin), and that the apparent high threshold in the normal subject is due to tubular recovery. It is possible therefore that there is a defect in tubular activity which accounts for the low threshold in cases of march hæmoglobinuria.

Miller and McDonald (1950) have produced evidence that free hæmoglobin induces renal vasoconstriction. The resulting ischæmia may alter the glomerular permeability for protein and so explain the association of proteinuria with hæmoglobinuria in this and other conditions.

No treatment has been found to have any consistent influence on the condition. Large doses of ascorbic acid have produced a cessation of hæmoglobinuria in 4 cases (Palmer and Mitchell, 1943), but have failed to do so in others and were without effect in *Case* 1.

Chaiken, Whalen, Learner, and Smith (1953) produced a prolonged remission in a case after the administration of 25 mg. of ACTH.

SUMMARY

Two cases of march hæmoglobinuria are recorded. The aetiology of the condition is discussed. An impairment of tubular recovery of hæmoglobin is suggested as a possible explanation for the low renal threshold to hæmoglobin in this condition.

I am most grateful to Dr. J. Ronald and Dr. H. A. Sissons for their advice and criticism; and to the War Office for permission to publish these cases.

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ANEURYSM OF RENAL ARTERY AND ARTERIAL HYPERTENSION

By DOUGLAS MILLER and J. GARVAN, St. Vincent's Hospital, Sydney

Severe arterial hypertension as a direct and reversible effect of renal artery abnormality is exemplified in the following case report :—

CASE REPORT

A girl, aged 16 years, undergoing a routine medical examination in 1950, was found to have a severe degree of hypertension. This had not been noted three months previously. She was referred to the care of Dr. Freeman, who admitted her to hospital where she was treated with hypotensive agents without effect.

Four months after discovery of her hypertension she was admitted to the Neurosurgical Unit at St. Vincent's Hospital for thoracolumbar sympathectomy. Her blood-pressure registered systolic 210 mm., diastolic 145 mm. (*Fig.* 490). There was considerable cardiac enlargement. Blood-urea was 24 mg. per cent, and the electrocardiogram was normal.

Plain radiographs of the renal area (*Fig.* 491) showed a small calcified double-ring area in the region of the hilum of the left kidney. Pyelography demonstrated that this shadow was outside the renal pelvis. There was doubt as to its nature.

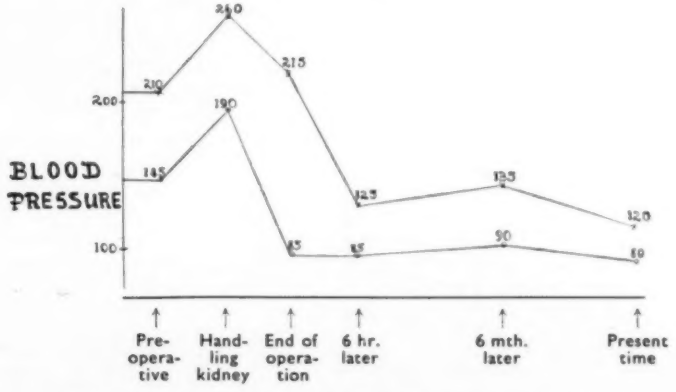


Fig. 490.—Pre- and post-operative blood-pressure readings.

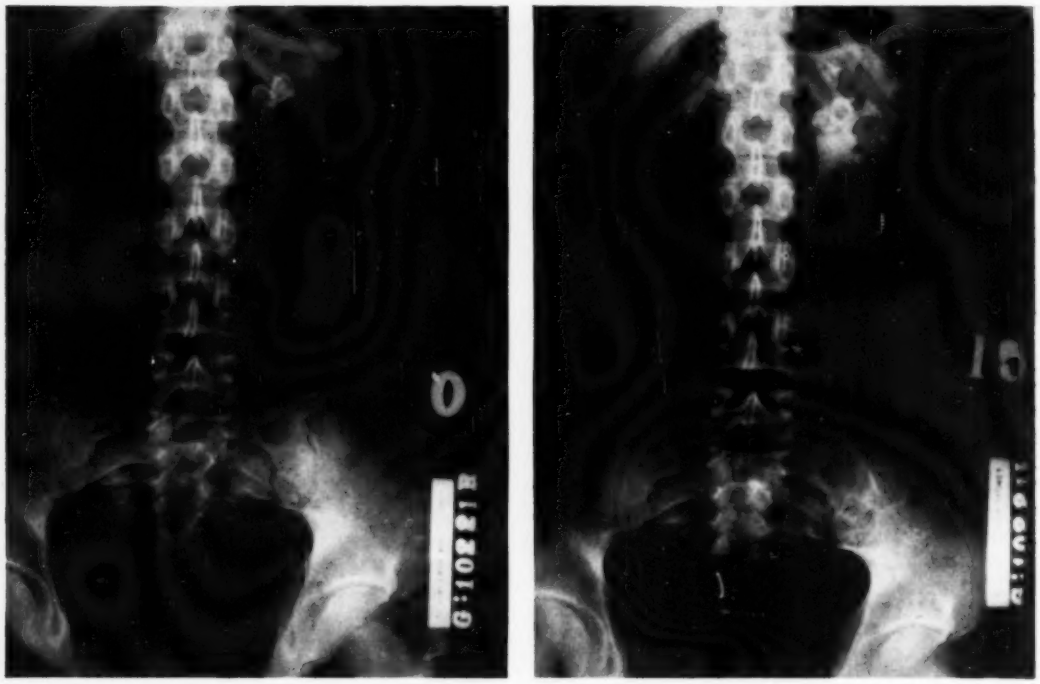


Fig. 491.—Radiographs showing small calcified area in region of hilum of kidney.

At Operation.—The incision of Fey, used as a routine for thoracolumbar sympathectomy, provided good access for careful examination of the renal pelvic region. The renal artery was found to be expanded by a small fusiform aneurysm immediately before entry into the kidney substance. This was felt to be pulsating strongly. During the manipulation of the kidney the blood-pressure

rose sharply to systolic 260 mm., diastolic 190 mm. (*Fig.* 490.)

The renal artery was then tied and the kidney removed. The blood-pressure immediately began to fall and at the end of the operation it was systolic 215 mm., diastolic 85 mm. Six hours later it was systolic 125 mm., diastolic 85 mm. (*Fig.* 490.) Thoracolumbar sympathectomy was not performed.

PROGRESS.—She made a good recovery, and six months later the pressure was systolic 135 mm., diastolic 90 mm. Some time later she became pregnant and in view of the history, her obstetrician terminated the pregnancy. It was not long before she was again pregnant and on this occasion she was allowed to run to full term and no rise of blood-pressure occurred. Now three years after operation her blood-pressure is normal.

PATHOLOGICAL NOTE (J. Garvan).—" The specimen is a left kidney weighing 93 g. The renal artery shows a dumb-bell-shaped aneurysmal dilatation—the proximal sac measures 1·8 mm. and the distal 1·5 mm. in diameter. The wall is densely calcified. The lumen of the aneurysm in the distal portion has been reduced to a diameter of 2 mm. by a calcified plaque. Five small arteries arise from various portions of the aneurysm and pass into the hilum. An aberrant renal artery of 3 mm. external diameter enters the hilum at its inferior border and a smaller vessel was in intimate association with the anterior surface of the pelvis. (*Fig.* 492.)

" The splenic area is seen to be flattened and depressed below the general surface of the kidney. It is suggested that this macroscopic appearance is due to hypoplasia of the renal tissues supplied by the arterial branches arising from the aneurysm.

" Two blocks were taken for microscopic examination, one from the depressed area and the other from the tip of the lower pole. Serial sections were prepared from these blocks.

" Two sections from the lower pole show the following features : There is no increase in interstitial tissue. The tubules show no significant change. There is some variation in the size of the glomeruli, but the average would be within normal limits. The outstanding feature

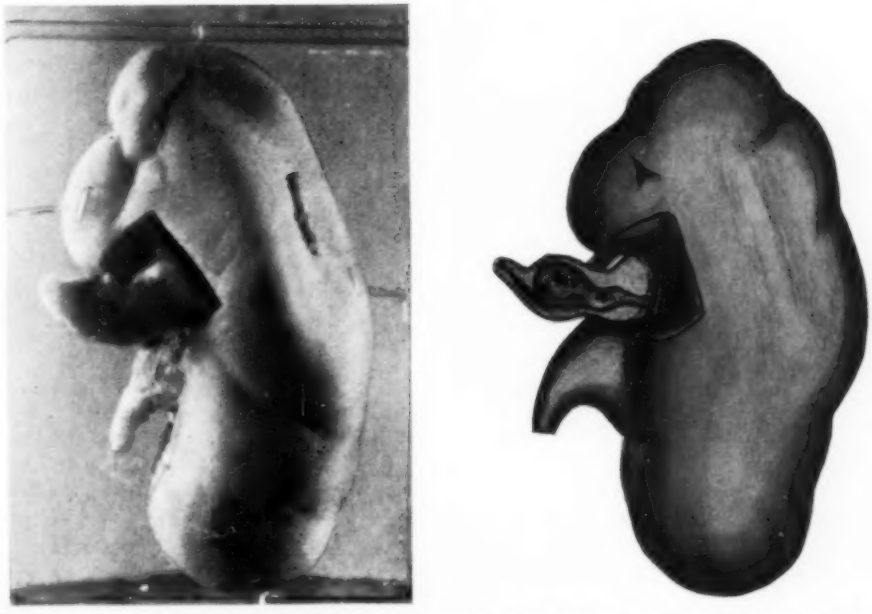


FIG. 492.—Excised kidney showing the dumb-bell shaped aneurysm, with the small arteries which pass into the hilum.

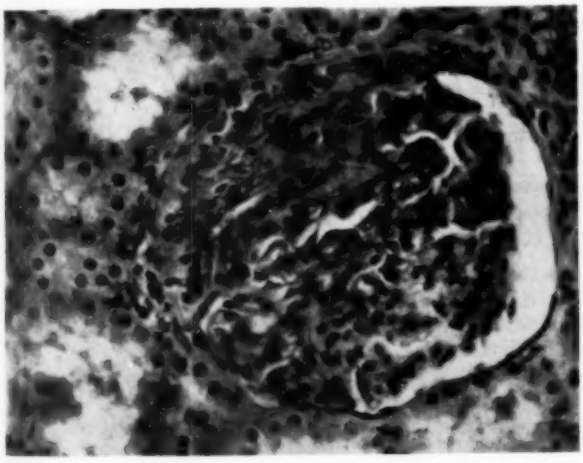


FIG. 493.—Showing endothelial proliferation of a glomerular tuft with ' crescent ' formation and adhesion to Bowman's capsule. (× 180.)

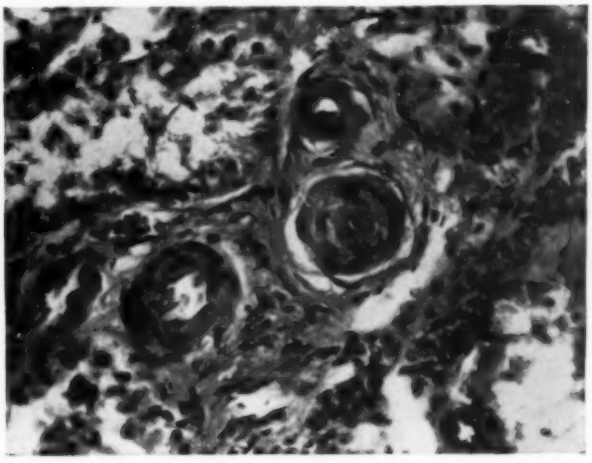


FIG. 494.—Showing marked reduction of the lumen of an arteriole by subendothelial fibrosis. (× 180.)

is the presence of an occasional glomerulus showing an epithelial crescent and thickening of Bowman's capsule. The smaller arteries show hypertrophy of the media and reduplication of the internal elastic lamina. None of these changes could be found in the sections of the block taken from the depressed area of the upper pole. (*Figs.* 493–495.)

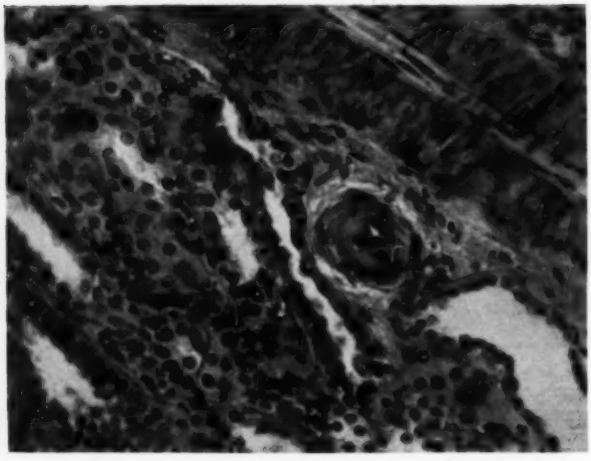


FIG. 495.—Showing a hyalinized arteriole. (× 180.)

"The aetiology of the aneurysm is obscure, but I suggest that it may be the result of a congenital abnormality of the renal artery. The significance of the histological changes in the lower pole of the kidney again is difficult to assess. They do resemble the lesions seen in malignant hypertension and may be regarded as the result of a partial slow ischæmic defect in the upper pole of the kidney resulting from the aneurysm, and in that case probably reflect similar changes in the other kidney."

DISCUSSION

This appears to constitute a good example of a natural Goldblatt clamp experiment. The pathological changes are characteristic of those produced by experimental renal ischæmia. It is interesting to note that though the aneurysm had been present probably throughout life, and certainly long enough to be calcified, the hypertension was apparently of short duration and irreversible changes had not had time to develop in the other kidney.

The cause of the ischæmia secondary to the aneurysm remains a matter for speculation. No thrombosis had occurred in the aneurysm, but a calcified plaque had reduced the lumen to a diameter of 2 mm. in one place.

It is possible that this reduction in calibre was a recent event responsible for the onset of the hypertension, though an added element of spasm may have been superadded.

THE VALUE OF CYSTO-URETHROGRAPHY IN PARAPLEGIA

BY M. DAMANSKI AND A. SUTCLIFFE KERR

FROM THE LIVERPOOL REGIONAL PARAPLEGIC UNIT, PROMENADE HOSPITAL, SOUTHPORT

THIS paper is based on radiological studies of various types of urinary bladder activity in cases of paraplegia over a period of six years carried out at the Southport Paraplegic Unit.

In order to demonstrate the outline of the bladder and urethra by radiography it is necessary to fill their cavities with a radio-opaque medium. The X-ray film of the bladder taken after it has been filled with contrast medium is called a cystogram, and a similar film of the urethra is called a urethrogram. The combination of both pictures is called a cysto-urethrogram, and the main purpose of this paper is to demonstrate how useful this method can be in cases of paraplegia. Altogether, 250 cysto-urethrographies have been carried out on 100 patients.

Cysto-urethrography is supplementary to other methods of investigation. It gives a graphic and permanent record of anatomical and physiological changes of the bladder-neck and the posterior urethra and is particularly useful before making a decision as to the future course of surgical treatment for a patient suffering from high residual urine. The cysto-urethrographic pictures before and after any surgical procedure may be studied and compared.

The method is contra-indicated in patients suffering from acute epididymitis, a flare-up of urinary infection, or an acute peri-urethral abscess.

METHODS OF CYSTO-URETHROGRAPHY

There are two methods of radiographic examination of the lower urinary tract—excretory and retrograde cysto-urethrography. Radiographs obtained by the retrograde method do not represent the condition of the bladder and the urethra as truly from the physiological point of view as does the excretory method. The introduction under pressure of a hypertonic and heavy contrast medium may cause changes in the tonus of the detrusor muscle and consequently in the shape of the bladder and of its sphincters, but the improved contrast is an indispensable advantage and a much better diagnostic picture is obtained. In the excretory method there is sufficient contrast medium to outline the small capacity of the renal pelvis and ureter, but the larger cavity of the bladder may not be so accurately demonstrated and certainly the posterior urethra cannot be adequately visualized in the excretory method.

TECHNIQUE OF RETROGRADE CYSTO-URETHROGRAPHY

Preparation.—The rectum should be well evacuated to avoid filling defects from fæcal masses and gas.

A bladder syringe of 4 or 8 fl. oz. is used.

Control Film.—A control film in anteroposterior projection is taken first. Later a soft rubber catheter

is passed with strict aseptic precautions, the residual urine evacuated and the bladder filled with 8 fl. oz. of 10 per cent sodium iodide. A contracted bladder may be incapable of holding the full quantity and only gentle pressure must be used on the injecting syringe.

Resting Films.—The first film is an anteroposterior exposure with the patient supine, the central ray being directed to the upper margin of the symphysis pubis at an angle of 5° towards the feet. A right or left oblique exposure follows, the transverse axis of the patient's body being tilted at an angle of 50–60° to the table, and the central ray being directed vertically through the upper margin of the symphysis pubis. The leg nearest to the table is flexed to an angle of approximately 45° at the hip and knee-joints, the leg farther from the table being extended fully.

Voiding Films.—The two films at rest are followed by two films during micturition, the patient being instructed to micturate by his usual routine.

Retrograde Filling Films.—Frequently the voiding films are not satisfactory and retrograde filling of the urethra and bladder is necessary. A very smooth-acting syringe is essential to obtain a steady flow of the fluid during the exposure.

Film for Backflow.—The examination is finished by taking an anteroposterior film of the renal tracts to show any ureteric backflow. Finally all the contrast medium must be evacuated through the catheter.

Shielding from X Rays.—During the exposures the examiner uses a lead-rubber glove on the hand holding the penis, and the radiographer holds a lead plate to protect the examiner's hand holding the syringe.

DIFFICULTIES

Aseptic conditions at the X-ray department are sometimes difficult to obtain and it is best to have a trolley provided and laid by the ward staff. When doing the retrograde filling with a lead-rubber glove on, this must not come in contact with the nozzle of the syringe. In the non-circumcised patients the prepuce tends to slip forwards.

Arranging the patient's legs is often a difficult matter owing to strong spasticity and/or joint contractures. The patient may also move away from the casette owing to involuntary spasms.

Micturition films are often difficult to obtain as the act may be initiated unexpectedly and this makes synchronization difficult.

A stiff syringe or a cold contract medium may cause a traumatic injection with ill-effects like overdistension of a small capacity bladder, ureteric backflow, spasm of the sphincters, urethral bleeding, and extravasation of the medium.

THE RADIOLOGICAL APPEARANCES OF A NORMAL BLADDER

The bladder outline changes with the quantity of the injected contrast medium. First it is flat or concave, its base being at or slightly above the level of the symphysis pubis. Later it expands in all directions except the base, its outline becoming progressively oval or ovoid, round, and conical. Impressions from the adjacent organs are not uncommon. On oblique projection its greater diameter runs transversely or obliquely, in the latter case the anterosuperior shadow being higher than the postero-inferior one. This may show superimposition of two shadows of different density in the anteroposterior projection and should not be mistaken for a diverticulum. At the beginning of the micturition the dome of the bladder moves upwards and dorsally and the lateral walls medially. As the pelvic floor relaxes, the bladder base and the internal orifice are displaced downwards (Muellner, 1951), assuming a funnel-shaped appearance.

FIG. 496.—Cysto-urethrogram to show diverticulated bladder of inverted-cone shape owing to relaxation of the proximal prostatic urethra. Note the lesser degree of relaxation of the distal prostatic urethra and the contracted external sphincter. Left seminal vesicle outlined by contrast medium. Clinically there is high degree of urinary infection, recurrent epididymo-orchitis, and repeated breakdowns of the surgically closed S.P. cystostomy. Recently a stone was removed from the right kidney.

THE RADIOLOGICAL APPEARANCES OF A PARAPLEGIC BLADDER

In some patients the outline of the bladder remains smooth (*Figs.* 501 A, 502 A), but a great majority show trabeculated contours varying from a slight trabeculation (*Figs.* 504 A, B, C, D, 505 A, B) to considerable diverticulosis (*Figs.* 496–498, 502 B, 503 B, 505 E, F). A single and narrow-neck diverticulum and an hour-glass bladder were also found. Impressions from a loaded rectum or colon are common. Apart from the common superimposition of fundal shadows, there may be another superimposition from a pouch (*Figs.* 497, 498, 503 A), or a urachus patent at the vesical end, directed upwards. The pouch is not visualized on the anteroposterior projection if directed downwards, and the oblique film should be studied in every case.

Some very trabeculated bladders have an irregular and very conical, sometimes rhomboid appearance, in the anteroposterior projection (*Fig.* 497). In the oblique projection the angle of inclination of the long axis to the horizontal line may be much increased, the axis becoming vertical or almost so (*Figs.* 499, 502 B). The more the angle opens in the oblique

projection, the more erect the bladder looks in the anteroposterior view. The long axis of the bladder may be tilted downwards and forwards in patients with an increased pelvic tilt.

BACKFLOW TO THE UPPER URINARY TRACTS

Roughly speaking, there are three degrees of blackflow :—

1. Backflow to the lower third of one or both ureters (*Figs.* 504, C, D).

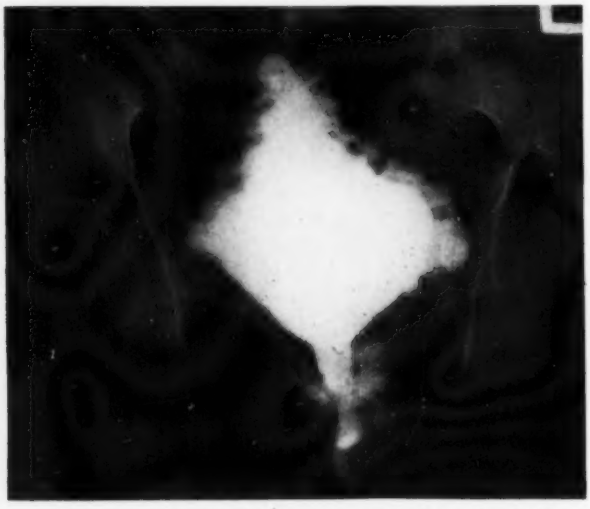


FIG. 497.—Cysto-urethrogram demonstrating a rhomboid-shaped bladder with a fringe of small diverticula. Prostatic ducts outlined by contrast medium. High degree of urinary infection, hydronephrosis, death from uræmia.

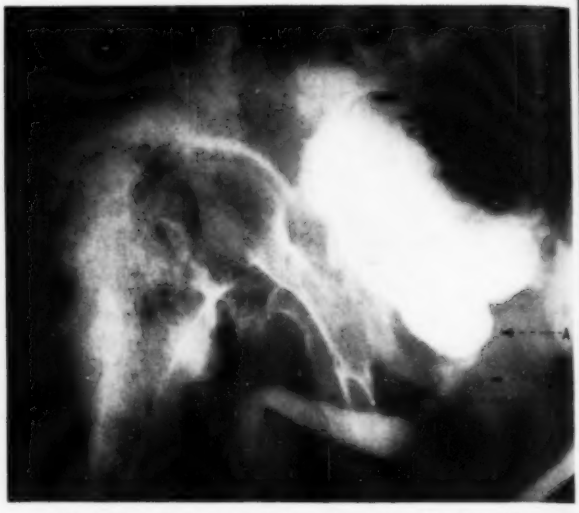


FIG. 498.—Cysto-urethrogram demonstrating the different degree of relaxation of the proximal and distal prostatic urethra, the external sphincter being short and tight. Note the ragged appearance of the distal sector anteriorly. Diverticulated bladder, anteverted pouch at the top. High degree of urinary infection. A, Proximal part of prostatic urethra ; B, Distal part of prostatic urethra ; C, Membranous urethra.

FIG. 499.—' Pseudosphincter '. The narrowest part of the posterior urethra is at the verumontanum.

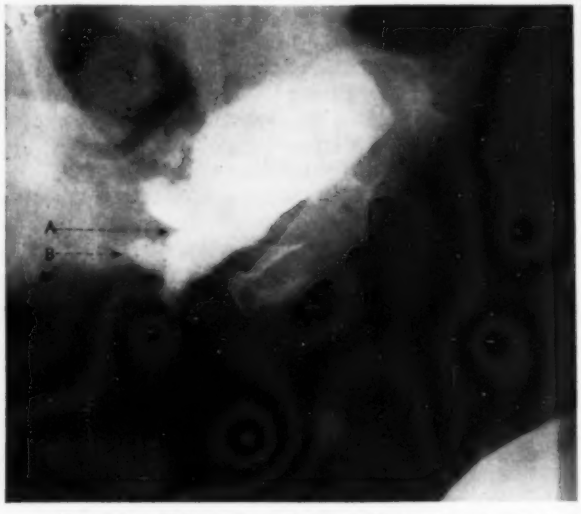


FIG. 500.—This cysto-urethrogram shows a large cavity in the prostate freely communicating with the urethra ; probably the result of a prostatic abscess. Note the median bar. A, Median bar. B, Abscess cavity.

2. Backflow up to the renal pelvis and calices on one or both sides with no or little distension.

3. Backflow with advanced dilatation of the whole upper tract or tracts. There is much looping, often with irregular narrowings, of the ureter or ureters.

Comments.—The introductory catheterization of the patient affords an opportunity to assess his residual urine, but inferences from the manner in which the patient is able to evacuate the contrast medium should be made with caution. Many patients are able to void the contrast medium in the radiographic room, even if they were previously unable to micturate satisfactorily. The reverse may also be true.

It is believed that the retrograde filling may increase the tonus of the detrusor muscle and produce conditions similar to those obtained during micturition against resistance. The erect bladder shape is possibly a cystographic artefact.

Assessing the bladder shape from the anteroposterior projection may be very misleading.

Backflow into the lower part of the ureter may be produced by overdistension of the bladder and it can be overlooked unless the so-called ' squat-shot ' radiographic technique (Boyce, Harris, and Vest, 1953) is used. The backflow is often a delayed sign, best seen on the last film.

STUDIES OF THE POSTERIOR URETHRA

NORMAL POSTERIOR URETHRA

A urethrogram taken in a supine anteroposterior projection shows the posterior urethra in the midline of the body. The verumontanum is visualized as a filling defect of variable length and serves as a valuable mark. The bulbous urethra tapers towards the membranous urethra.

The oblique view is of greater value. The course of the posterior urethra is slightly curved with the concavity anteriorly. The collicular area has the widest anteroposterior diameter.

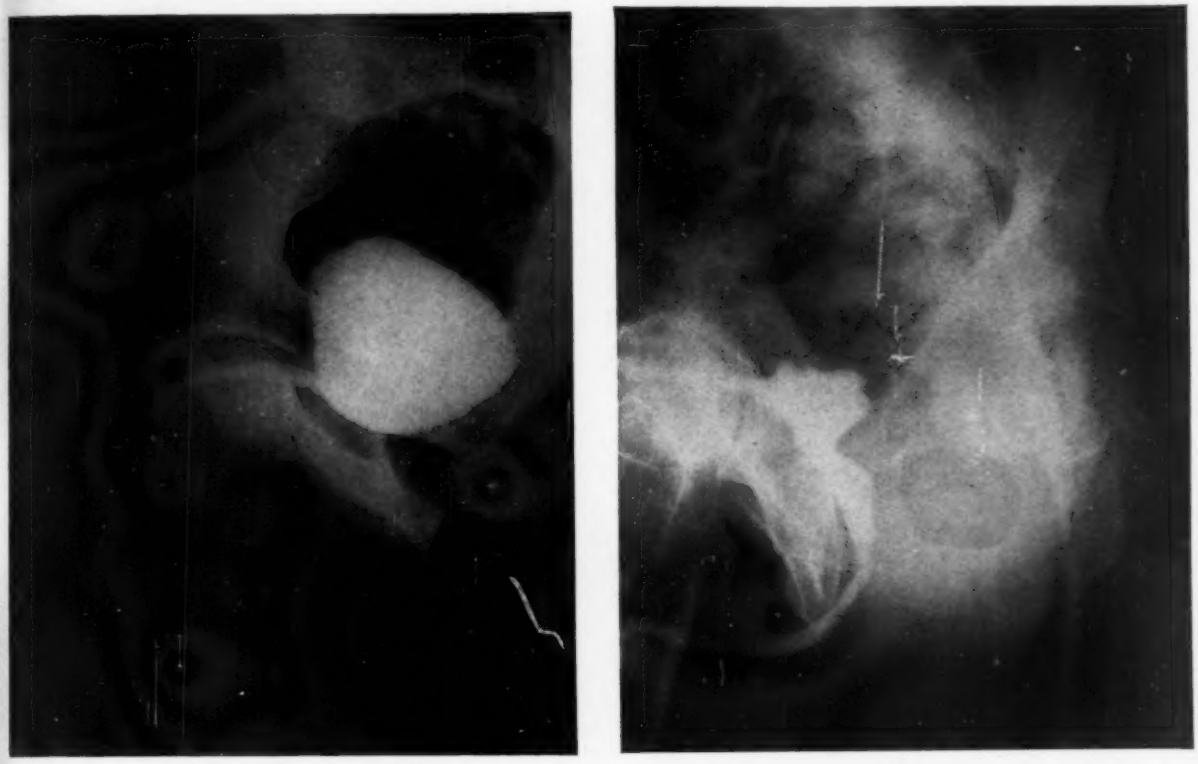
Normal prostatic ducts do not fill with contrast medium.

THE POSTERIOR URETHRA IN PARAPLEGIA

Length.—We have found the total length to vary between 18 mm. and 60 mm. (Compare *Figs.* 501 B and 502 A.)

Typical Pictures.—

Posterior Urethra contracted.—This is the most common picture in fresh paraplegia and in many cases of long standing. The posterior urethra is



A B

FIG. 501.—A, Cysto-urethrogram, oblique view, before a pudendal neurectomy (Sept. 6, 1951). No fluid passes beyond the verumontanum despite high pressure above. Note also the increased anterior tilt of the proximal prostatic urethra. B, Cysto-urethrogram, oblique view, after a pudendal neurectomy (Feb. 7, 1952). The bladder empties freely and there is relaxation of the whole posterior urethra. Note the considerable length of the posterior urethra (50 mm.).

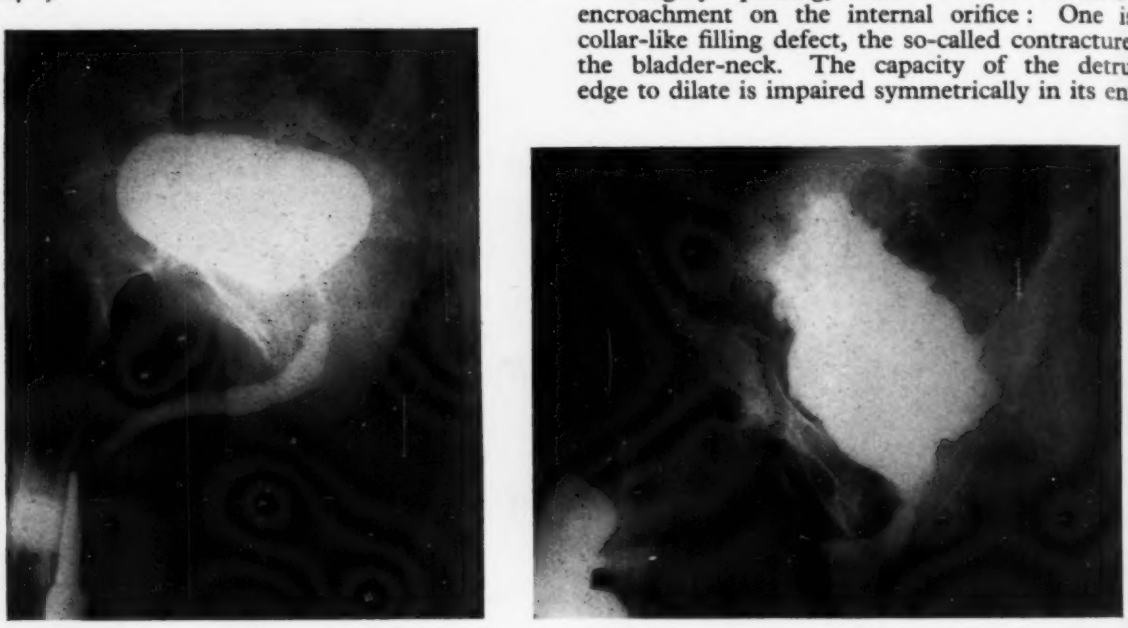
The length of the posterior urethra from the centre of the verumontanum, i.e., the colliculus seminalis to the internal orifice, the so-called supracollicular distance, and from the same centre to the junction with the bulbous urethra, the so-called infracollicular distance, are significant. There is a difference of opinion about the anatomical length of the posterior urethra. Rolnick and Arnheim (1949) have found that the average measurement of the supracollicular distance is 1·6 cm., and that of the part of the infracollicular distance to the external sphincter 0·8 cm., the total length of the prostatic urethra being 2·4 cm. The average length of the membranous urethra is said in Lowsley and Kirwin's *Clinical Urology* (1940) to be 1·5 cm.–2 cm.

extremely narrow, the length and the ratio of supracollicular to infracollicular distance varying greatly.

There is also another group of patients, those with a suprapubic catheter in position, mainly with a bladder of reduced capacity, in whom it is impossible to force the contrast medium from the bladder much beyond the internal orifice. By applying increased pressure from above, it is possible to distend some of the proximal prostatic urethra and find an impassable narrowing at the level of the verumontanum (*Fig.* 501 A). When attempting to visualize the posterior urethra from the external orifice, strong resistance is encountered at the external sphincter and no filling of the posterior urethra from below can be obtained.

Prostatic Urethra relaxed.—This pattern is usually found in paraplegics with a lower motor neurone lesion, but it is not uncommon in the upper motor neurone lesions. There can be three variants of this condition.

1. This group of patients comprises those whose prostatic urethra is relaxed proximally, and contracted distal to the collicular impression (*Figs.* 502 A, 504 A).



A B

FIG. 502.—A, Cysto-urethrogram showing an almost completely contracted posterior urethra and a median bar before a bladder-neck resection (March 13, 1952). The internal orifice is located higher and more posteriorly than the bladder base. Note the smooth bladder outline and the very short posterior urethra (18 mm.). The impression of the verumontanum is clearly seen. B, Cysto-urethrogram after a bladder-neck resection (Feb. 15, 1955). Complete relaxation of the bladder-neck and the posterior urethra. Note the rough bladder outline due to the severity of the intervening urinary infection.

2. The prostatic urethra is relaxed proximally, less relaxed distally, and the external sphincter area is short and contracted (*Figs.* 496, 498).

3. The prostatic urethra as a whole is widely patent, the external sphincter is short and tight (*Figs.* 503 A, 504 C, D).

External Sphincter relaxed.—There is easy and wide relaxation of the external sphincter on voiding and/or retrograde filling films (*Figs.* 497, 501 B, 503 B, 505 E, F). In some patients the cone of the bulbous urethra can be seen excessively elongated and reaching the verumontanum area (*Figs.* 504 B, 505 A). If there is also relaxation of the proximal prostatic urethra, the two sectors are separated by a constriction at the collicular level, which might be the radiological equivalent of what is called cystoscopically a pseudo-sphincter (*Figs.* 499, 505 C).

Dilated Prostatic Ducts.—About one-third of our patients have shown dilated and contrast-filled prostatic ducts, varying in degree from a tiny spot of contrast medium to an almost complete prostatogram (*Fig.* 497). Cavities resulting from abscess (*Fig.* 500) and contrast-filled seminal vesicles (*Fig.* 496) can be found occasionally.

Special Features of the Internal Orifice.—There are comparatively few cases where the transition of the bladder-neck into the prostatic urethra is smooth and funnel-like on both views. There is usually an angular junction and also a ring-like narrowing. Some of the films displaying a funnel-like junction on the anteroposterior projection show a definite posterior protrusion into the lumen of the internal orifice on the oblique projection. Compare *Fig.* 504 C with 504 D, and 505 C with 505 D.

Roughly speaking, there are two varieties of encroachment on the internal orifice: One is a collar-like filling defect, the so-called contracture of the bladder-neck. The capacity of the detruser edge to dilate is impaired symmetrically in its entire circumference, giving the prostatic urethra a spindle-shaped appearance (*Figs.* 504 A, B).

The other variety is a posterior filling defect. A wide gradation is possible, from an almost common angular junction (*Fig.* 499) to a definite posterior fold or mass, the so-called flap-valve, referred to cystoscopically as a median bar (*Figs.* 500, 502 A, 503 A, 505 B). In case the posterior lip is situated higher than the anterior one, the plane of the internal orifice is tilted and it opens obliquely forwards instead of upwards (*Figs.* 502 A, 503 A, 505 D).

Comments.—The state of contracted posterior urethra does not differ radiologically from the normal appearance.

It is difficult to find an explanation for the variations in length of the posterior urethra. The notoriously small prostate in paraplegic patients and the young age of the patient account for the shortness in many cases. Generally, great caution should be exercised when interpreting the changes. Grouping into the above-described classes can be doubtful or impossible in many cases. There is much scope for personal interpretation.

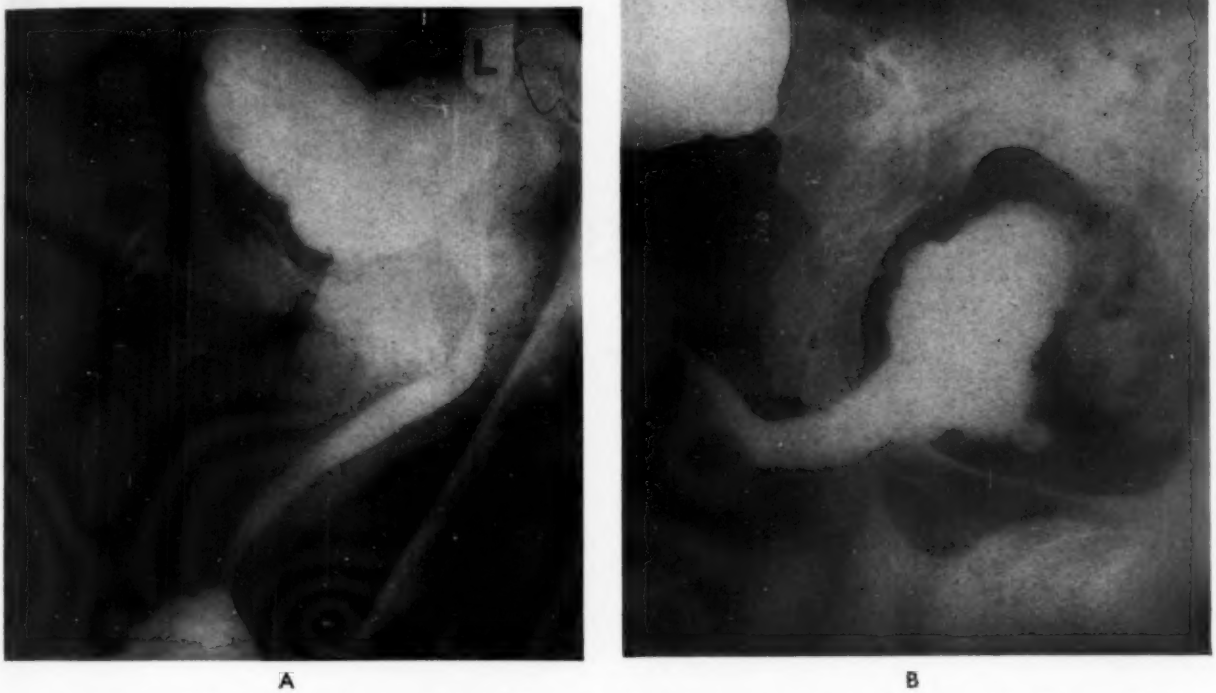
The posterior urethra passes through the prostate, and there may be all combinations of pretraumatic condition and inflammatory and neurogenic changes

(Edling, 1952). Elongation (*Fig.* 501 B), increased anterior tilt (*Figs.* 501 A, 503 A, 505 B, D), posterior tilt, lateral deviation (*Fig.* 505 A), irregular outline (*Fig.* 498), all can be encountered alone or with other changes and can be assessed only by considering the whole clinical picture.

Contrast-filled prostatic ducts and cavities are one of the radiological representations of inflammatory changes.

The true length of the distal part of the posterior urethra can be measured only on the oblique film.

It is easy to be misled when assessing which sector of the posterior urethra is relaxed unless one can define clearly the collicular outline and the proximal tapering of the bulb. It is felt that the three variants of relaxation are the radiological representation of relative length of the striated musculature of the external sphincter and the difference is a matter only of degree.



A B

FIG. 503.—A, Cysto-urethrogram after two alcohol blocks and before a bladder-neck resection (Nov. 24, 1954). The prostatic urethra is relaxed, there is a median bar and a contracted external sphincter. Note that the posterior lip of the bladder-neck is higher than the anterior lip. Some prostatic ducts are outlined. B, Cysto-urethrogram after a bladder-neck resection (Feb. 2, 1955). The median bar has been removed, the bladder-neck and the whole of the posterior urethra have relaxed considerably.

When comparing the films obtained by the retrograde and the excretory method, a difference in degree of relaxation can often be found. Retrograde cysto-urethrographs may in part be artefact, but they do visualize radiologically the difference in tonus between the parts of urethra.

In some cases differentiation is difficult between the 'contracture of the bladder-neck' and obstruction by a 'median bar'. Here again, this may be a matter of location and degree of change of the same nature.

GENERAL DISCUSSION WITH ILLUSTRATIVE CASES

All patients with a fresh and complete paraplegia, and most patients with an incomplete lesion, suffer from retention of urine for several months. Nothing can be done to reduce this period unless recovery of normal function of the spinal cord occurs. Whether an indwelling catheter (with or without tidal drainage) or a suprapubic cystostomy is used, infection follows almost inevitably. Even if satisfactory automatic or autonomous action occurs, many patients are left with a high residual urine and something must be done to reduce it because of the danger to the upper urinary tract. Cysto-urethrography should be performed at this stage together with other investigations.

Cystography renders invaluable service in assessing the damage to the urinary tract already done by the infection. A highly trabeculated or diverticulated bladder or one of bizarre shape is characteristic of severe infection and many uræmic patients display this radiological picture (*see* legends to *Figs.* 496–498, 502 B). This is often associated with dilated prostatic ducts or cavities (*see Figs.* 496–498, 500. 503 A). Backflow to the renal pelvis with dilatation is prognostically bad (Damanski and Gibbon, 1956) and augurs functional loss of the affected kidney. Any delay in embarking on surgical procedures is undesirable. On the other hand, any procedure carried out in the circumstances of heavy urinary infection has less chance of success.

Urethrography provides radiological visualization of the site and nature of an obstruction and is

a help in choosing the appropriate procedure to relieve it.

Two neurosurgical procedures, i.e. a pudendal neurectomy (Ross and Damanski, 1953; Bors and Comarr, 1954) and/or a subarachnoid alcohol block (Shelden and Bors, 1948), or a urological procedure, i.e., a bladder-neck resection, may be employed.

The neurosurgical procedures have a chance of success in upper motor neurone lesions in the absence of advanced fibrous metaplasia of the muscular fibres. Bladder-neck resection, applicable in both upper and lower motor-neurone lesions, removes the obstruction mechanically and may have a myotomy-like effect.

A short summary of a few typical cases supported by cysto-urethrograms taken before and after the appropriate procedure illustrates how the method helps to establish the indication and to interpret the result.

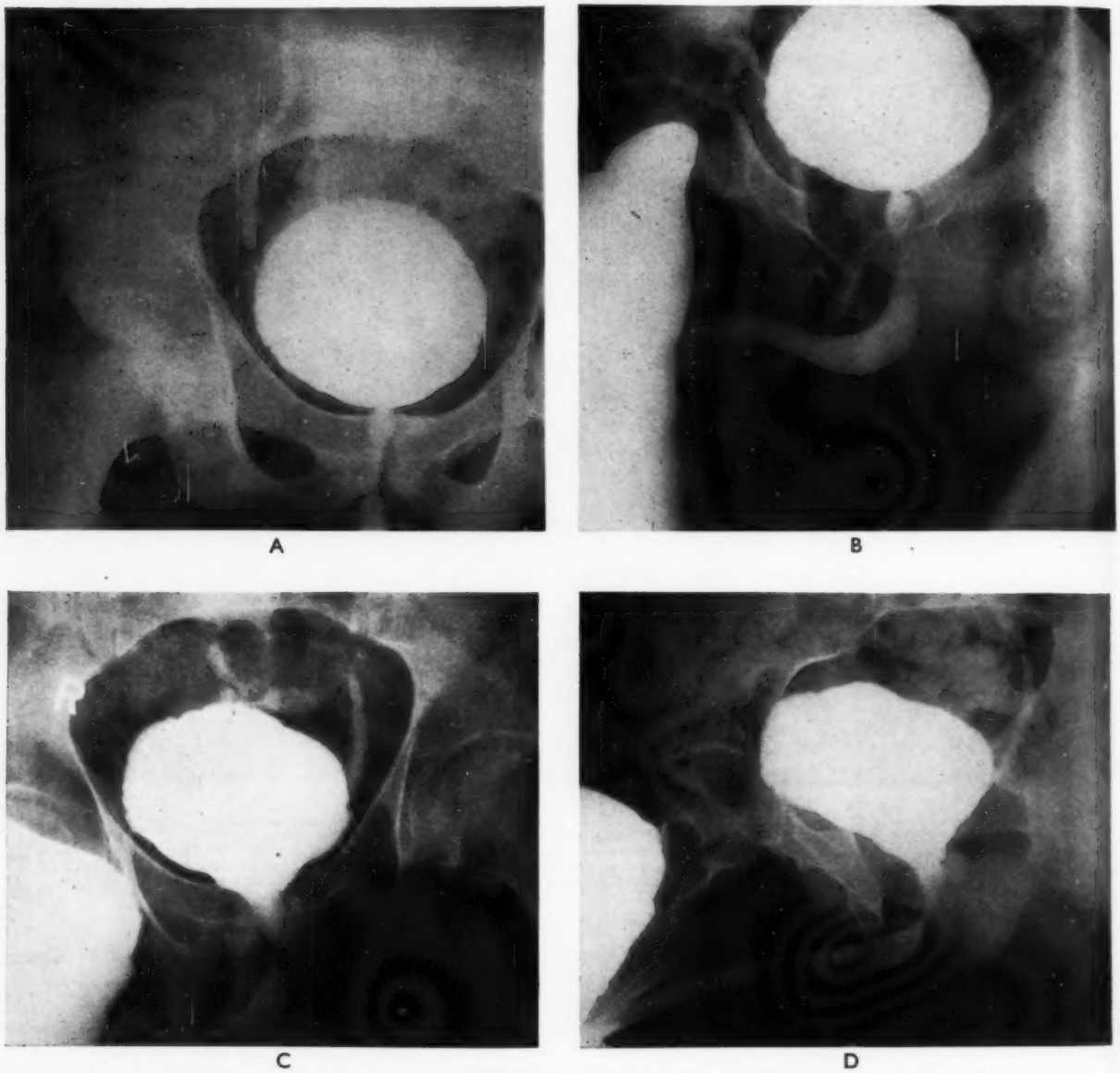


FIG. 504.—A, B, Cysto-urethrograms, anteroposterior and oblique views, before procedures (Nov. 3, 1954). Bladder-neck contracture and median bar. Proximal prostatic urethra open on both views, external sphincter slightly relaxed on the oblique view. Note round bladder shape and backflow to the right ureter. C, D, Cysto-urethrograms, anteroposterior and oblique views, final result (May 11, 1955), the main improvement occurring after a subarachnoid alcohol block of 10 c.c. Note the descent of the bladder-neck and considerable relaxation of the prostatic urethra. There is still a trace of median bar. Note also backflow to the left ureter.

1. Pudendal Neurectomy performed for Spasticity of the Whole Posterior Urethra.—

Case 1.—J. A. H., aged 27 years. Spastic and incomplete paraplegia at and below T.10 level, due to transverse myelitis. Complete retention of urine.

No micturition films could be obtained, resting films showed a contracted posterior urethra. A set of post-operative voiding films showed good relaxation of the posterior urethra.

Clinical result excellent, micturition with no residual urine.

Case 2.—J. S., aged 29 years. Spastic and complete paraplegia T.11 due to fracture-dislocation T.11 on 12. Residual urine, 15–18 oz.

Pre-operative retrograde filling films showed that the whole posterior urethra was contracted, post-operative retrograde filling films showed relaxation of the whole posterior urethra.

Clinical result good, residual urine reduced to 5 oz.

Case 3.—M. B., aged 36 years. Spastic and complete paraplegia T.11 due to compression-fracture T.12. Residual urine, 12–15 oz. Bilateral hydronephrosis.

Pre-operative filling films showed that the whole posterior urethra was contracted. Post-operative voiding films showed very wide relaxation of the whole posterior urethra.

The clinical success was temporary only. A successful alcohol block was performed later. Marked improvement in the condition of kidneys has been obtained.

Case 4.—W. L. R., aged 31 years. Complete and spastic paraplegia L.1.2–3, due to fracture-dislocation T.11 on 12. S.P. cystostomy could not be closed as the patient was unable to micturate per urethram when the S.P. catheter was spigoted.

See Fig. 501 A, suprapubic filling, oblique projection. Very little relaxation of the proximal prostatic urethra obtained by forceful distension. Compare *Fig.* 501 B, post-operative suprapubic filling, oblique projection. The patient could not hold the contrast medium and passed it immediately after injection with complete relaxation of the whole posterior urethra.

Excellent clinical result. The S.P. cystostomy was closed and the patient has been able to empty his bladder with no residual urine.

2. Pudendal Neurectomy performed for the Spasticity of the External Sphincter.—

Case 5.—D. W., aged 44 years. Spastic and complete paraplegia T.4–7, due to fracture-dislocation T.5 on 6.

The patient had an alcohol block prior to the pudendal neurectomy, the secondary lower motor-neurone lesion being incomplete as the bulbocavernosus reflex was preserved. Residual urine, 8 oz. Frequent flare-ups of urinary infection.

Pre-operative films showed that the whole prostatic urethra was widely relaxed, the external sphincter area being short and narrow. Post-operative retrograde filling films showed a more considerable degree of relaxation of the prostatic urethra, and also a widely open external sphincter.

Clinical result good. Residual urine 2½ oz. Progress of the urinary infection arrested.

3. Effect of Subarachnoid Alcohol Block.—

Case 6.—N. L., aged 35 years. Spastic and complete paraplegia T.7–8, due to fracture-dislocation T.8 on 9. The patient had a pudendal neurectomy before, which was a failure; the denervation was incomplete as the anal reflexes remained preserved. High residual urine, 32 oz. The procedure was supplemented by two alcohol blocks of 2 c.c.

Retrograde filling films after neurectomy but before alcohol blocks showed almost completely contracted posterior urethra; those taken after the blocks demonstrated relaxation of the prostatic urethra.

Clinical result excellent. Residual urine reduced to 2–4 oz.

Case 7.—R. D., aged 30 years. Complete and spastic paraplegia T.5 due to fracture-dislocation T.4 on 5. After a surgical closure of the S.P. cystostomy the patient had complete retention of urine despite a pudendal neurectomy, two alcohol blocks of 2 c.c., and a bladder-neck resection. Another alcohol block, this time using 10 c.c., was performed.

Films taken before the 10-c.c. block showed a closed posterior urethra; those after the block demonstrated a completely relaxed prostatic urethra.

Dramatic improvement followed the last block, residual urine reduced to nil.

4. Effect of the Transurethral Bladder-neck Resection.—

Case 8.—J. W., aged 21 years. Spastic and complete paraplegia T.4 owing to fracture-dislocation T.3 on 4. The patient had an alcohol block for the spasticity of the skeletal muscles and a pudendal neurectomy for high residual urine. The anal and bulbocavernosus reflexes were abolished, but residual urine of 16 oz. remained unchanged. Finally he had a bladder-neck resection which reduced his residual urine to 2–3 oz.

See Fig. 502 A, pre-operative retrograde filling film, oblique projection. Note partial relaxation of the prostatic urethra and the median bar. Compare with *Fig.* 502 B, post-operative retrograde filling film. Note considerable degree of relaxation of the posterior urethra. No median bar remains.

5. Effect of Combined Procedures.—

Case 9.—H. H., aged 32 years. Spastic and complete paraplegia T.8 due to compression-fracture T.9. The patient had alcohol blocks twice to relieve the spasticity of the skeletal muscles. They were followed by relaxation of the prostatic urethra. The anal and bulbocavernosus reflexes were abolished and residual urine reduced to 2–5 oz. The patient developed bilateral hydronephrosis later, and despite the rather low residual urine it was considered wise to deal with the median bar.

See Fig. 503 A, pre-operative retrograde filling film, oblique projection. Note the relaxation of the prostatic urethra after the alcohol blocks and the narrow external sphincter. There is a median bar. Compare with *Fig.* 503 B, post-operative retrograde filling film, oblique projection. Note considerable relaxation of the whole posterior urethra and the absence of the median bar. Residual urine reduced to nil. Not yet followed-up for hydronephrosis.

Case 10.—L. S., aged 46 years. Complete and very spastic paraplegia T.8 due to compression-fracture T.8. Combination of a pudendal neurectomy with a bladder-neck resection and two alcohol blocks of 5 c.c., followed by another block of 10 c.c. Residual urine at first 30 oz.

See Fig. 504 A, B, retrograde filling films. Note the narrowing at the internal orifice and the contraction of the distal posterior urethra on A.P. projection. In view of the length of the contracted area, a pudendal neurectomy was done first. This was followed by a drop in residual urine to 20 c.c. Radiologically, there was relaxation of the external sphincter, the bladder-neck contracture still being present. In view of the persisting contracture, a bladder-neck resection was performed later with no clinical improvement. Two alcohol blocks, of 5 c.c. each, followed with a temporary drop of residual urine to 8–10 c.c. Radiologically, some funnelling of the bladder-neck was demonstrated. Another alcohol block, this time of 10 c.c., was performed.

Compare *Fig.* 504 C, D, retrograde filling films, A.P. and oblique. Note the excellent relaxation on both views. Residual urine dropped to 2–3 oz.

Case 11.—W. W., aged 48 years. Very spastic and complete paraplegia T.5–6, due to fracture-dislocation T.5 on 6. Residual urine 10 oz. *See Fig.* 505 A, B, retrograde filling films. Note the high degree of narrowing at the internal orifice caused by a shelf of tissue encroaching posteriorly and on the left side. Compare *Fig.* 505 C, D, films taken after a bladder-neck resection, A.P. retrograde

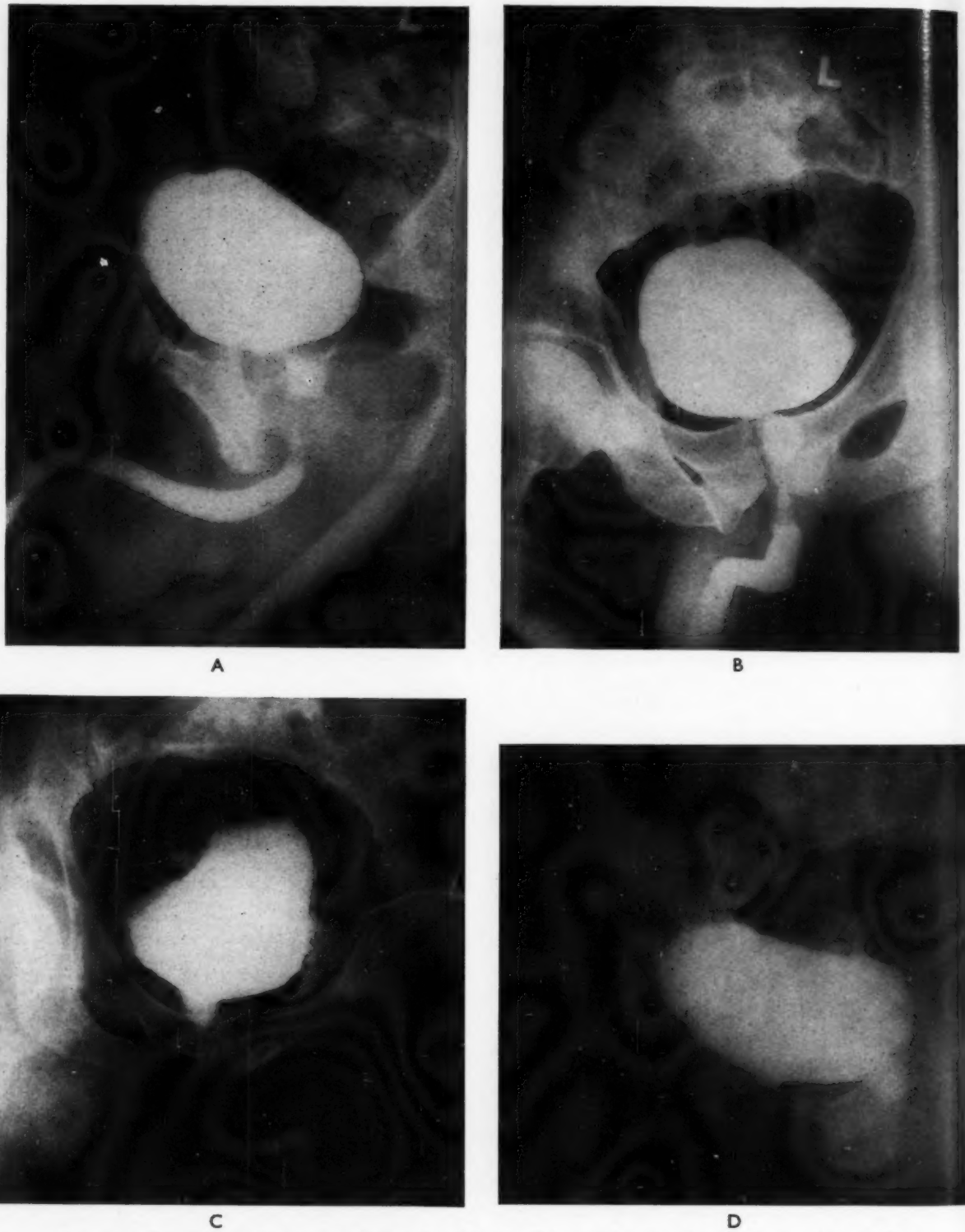
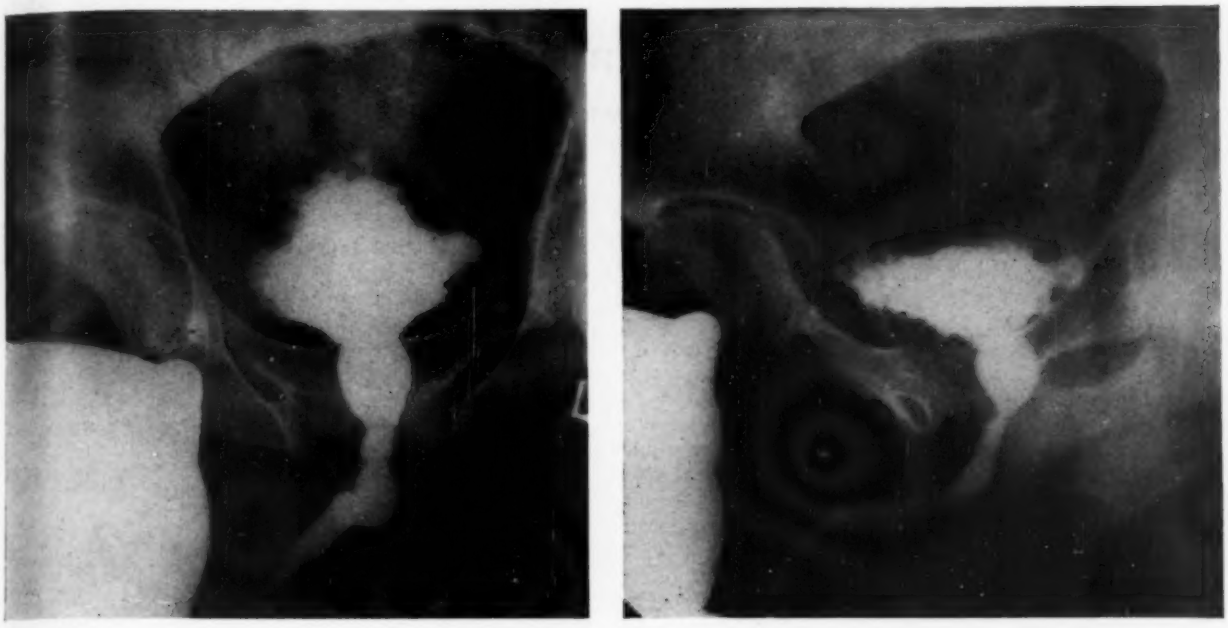


FIG. 505.—A, B, Cysto-urethrograms, anteroposterior and oblique views, before procedures (Nov. 3, 1954). Bladder-neck contracture, lateral deviation, and median bar. Proximal prostatic urethra relaxed, slight relaxation of the external sphincter. C, D, Cysto-urethrograms after a bladder-neck resection (Dec. 15, 1954). Note the funnel-shaped appearance of the proximal prostatic urethra on the anteroposterior projection. The median bar visualized on the oblique projection would have passed unnoticed if we had relied on the anteroposterior projection only. The posterior lip of the bladder-neck is higher than the anterior one. 'Pseudo-sphincter'. E, F, Cysto-urethrograms after an alcohol block (Feb. 9, 1955). The whole posterior urethra has considerably relaxed, including the bladder-neck contracture.



E F

FIG. 505—*continued.*

filling, oblique voiding film. Note the funnel-shaped proximal prostatic urethra on the A.P. projection; there is still a median bar on the oblique film.

Clinically the result was not considered satisfactory and an alcohol block of 5 c.c. was performed later to obtain further fall in residual urine and to control the spasticity of the skeletal muscles. It has been a complete success, residual urine dropped to nil.

See Fig. 505 E, F, retrograde filling films. Note the greater relaxation of the posterior urethra.

DISCUSSION

Many patients with a spinal cord lesion who develop automatic (reflex), autonomous, or assisted emptying of the urinary bladder are found to have a high residual urine while others have complete retention of urine for many months.

These conditions carry a high risk of damage to the upper urinary tract and must be relieved, if possible. Before the appropriate manœuvre can be selected, it is necessary to have as much information as possible regarding the functional activity of the lower urinary tract.

Cystoscopy and urethroscopy give essential information regarding the anatomical and pathological changes which may be present and cystometrograms assess the activity of the bladder musculature, but information concerning the function of the bladder-neck, the sphincters, and the posterior urethra can best be obtained by radiographic visualization.

The method of cysto-urethrography has proved invaluable in determining whether a case would be likely to respond to bladder-neck resection, to pudendal neurectomy, to intrathecal alcohol block, or to a combination of measures. It is also of value in assessing the response to any of the procedures.

SUMMARY

The methods and technique of cysto-urethrography have been described.

The usefulness of the method in diagnosing the severity of infection and establishing the indications for operative procedures has been discussed.

The practical application of the method has been illustrated by short case-histories.

Typical radiographs are demonstrated.

Acknowledgements.—We would like to acknowledge with gratitude the help and encouragement we have received from our colleagues on the Staff of the Southport Spinal Injuries Unit, Mr. J. Cosbie Ross, and Mr. Norman Gibbon, and in particular from the Radiological Department under Dr. K. D. Forgan Morle.

Our thanks are also due to Mr. W. Lee, of the Central Photographic Department of the University of Liverpool, for his work in preparing the illustrations.

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MESENCHYMOMA

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In 1943 J. R. Gilmour related the clinical story of a woman who at the age of 23 had a tumour removed from her back. During the course of the next twenty years, ten recurrent tumours of precisely the same type were removed from the same area. The tumour was found to consist of benign-looking tissue which closely resembled embryonic mesenchyme, differing from it, in fact, only in the presence of local excess of mucus which had led to the development of cystic spaces. He believed it to be quite different from a myxoma and in view of its peculiar histological structure and of its quite distinctive clinical behaviour he thought fit to separate it off from other tumours of connective tissue and to call it a 'mesenchymoma'. In 1951 Symmers and Nangle reported the later history of Gilmour's patient, who went on to develop further local recurrences during the next four years. These were in part controlled by repeated courses of irradiation. The patient eventually died of exhaustion. There was at this time a massive local recurrence but no distant metastases. They also put on record 3 further examples of this type of tumour, with a very complete clinical and histological record. Two more cases were described by Pemberton and Cromack in 1953, bringing to 6 the total number of cases reported to that time.

Recently we have had an opportunity of investigating and treating several patients with similar tumours, and we propose now to put on record 5 examples which we have traced in the files of Hammersmith Hospital during the past twenty years, thanks to the courtesy of our colleagues who have so generously given us access to their material.

Our main excuses for this paper and for presenting it in a general surgical journal are as follows :—

1. We believe that this is a tumour which in its clinical behaviour follows a very definite pattern which in turn largely determines our proper line of treatment.

2. Its gross appearance is so characteristic that it should be possible to recognize it at operation.

3. It is our belief that the condition is not widely known among surgeons.

We must, however, at the very outset, make it quite clear that we are in this communication dealing only with that type of tumour to which Gilmour gave the name 'mesenchymoma'. Unfortunately, it is not unlikely that he was at the time unaware that Klein (1932) and Cellina (1932) had almost ten years earlier used this same term to describe quite different types of connective-tissue tumours. We think it is unfortunate that Purdy Stout, who writes with such authority, has since used this term (1948, 1953) in a much wider sense for another group of connective-tissue tumours of a complex type. His example has been widely followed in American literature and most of the examples of mesenchymoma reported in the literature within recent years are of the type which he described.*

We believe that there is some merit in following the example of Symmers and Nangle and of restricting the use of the term mesenchymoma to " . . . neoplasms composed of more than one type of connective tissue, the structure of which is that of differentiating embryonic tissues which develop from and replace the primitive mesenchyme." This was Gilmour's definition and in this communication we hope to follow this usage closely.

CASE REPORTS

Case 1.—H. H., 153663.

June, 1950 : A woman in her late sixties first presented herself for treatment with a swelling on the back which had been present for about two years, and which was gradually increasing in size. It was quite painless. A large tumour was found in the lower dorsal region, apparently situated in the sacrospinalis muscle group. It measured 19 cm. across, and was thought to be a lipoma or a cold abscess. A radiograph of the spine was, however, negative. Attempts to aspirate the swelling were unsuccessful.

When the tumour was explored it was found to be myxomatous in nature and to lie near to the latissimus dorsi and trapezius muscles. It shelled out very easily and was reported elsewhere to be a mesenchymal tumour of a benign nature.

November, 1952 : An extensive recurrence was found in the muscles of the lumbar region. It consisted of many collections of rather gelatinous material, widely scattered in the sacrospinalis muscle and in the overlying subcutaneous tissue. Treatment was by wide local excision.

October, 1953 : Reported to Hammersmith Hospital (M. R. E.) with a second recurrence, this time in the scapular region immediately above the upper limit of the earlier incision. At operation the main tumour was found to consist of rather floppy, homogeneous, red gelatinous material which had no obvious capsule but which looked completely innocuous. There were however in the vicinity smaller collections of the same material, both in the muscle tissue and in the fascial planes, and it was a matter of considerable difficulty to decide just how wide the resection should be.

May, 1954 : A considerable portion of the sacrospinalis muscle group was sacrificed in the resection of a third recurrence, this time in the lower dorsal region. There was a separate deposit measuring a few centimetres across close to the medial margin of the right scapula.

June, 1955 : Three further separate local recurrences were noted at a routine follow-up examination. Two were removed with a wide margin of healthy muscle. One of them (*Fig.* 506) appeared to be well encapsulated. The third and largest extended deeply in the sacrospinalis towards the spinous and transverse processes of the upper lumbar vertebræ. Several of its loculations were cut across with spillage of their content following an attempt at its complete removal.

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* For a complete consideration of the problems of nomenclature, the reader should consult the paper of Symmers and Nangle (1951).

PATHOLOGY.—The histology has remained substantially unaltered throughout. In every tumour the basic structure has been that of a myxoma with stellate and spindle cells in a background of mucin. In some parts the mucin lies evenly between the cells, more often it has run together into lakes so as to give a false impression of an acinar structure (*Fig.* 507). The mucin stains well with alcian blue. This part of the tumour has a loose network of fine reticulin fibrils and a condensation of reticulin or collagen around vessels and in interlobular strands (*Fig.* 508). Generally this part of the tumour is a little more cellular than a pure myxoma but the cells are relatively uniform and do not appear anaplastic. Mitoses are very uncommon. Throughout the tumour there is a great excess of blood-vessels, generally of the size of venules but sometimes bigger. These have only an endothelium and a condensation of collagen in their walls. The number is grossly in excess of that needed to nourish the tumour and some foci have the structure of an angioma (*Fig.* 509).

In addition to these two elements, the tumour appears to be differentiating into fatty tissue, and primitive cells of mulberry shape containing multiple globules of fat can be seen in frozen sections. These are not frequent but appear to be a part of the tumour and not merely macrophages containing fat.

Apart from these three components, tissue mast cells are fairly frequent and one focus of hæmopoiesis was seen among many sections (*Fig.* 510).

Sections taken at the edge of the tumour in several of its recurrences showed fine strands of tumour running out between bundles of fibrous tissue and extending beyond the apparent limits of the visible tumour (*Fig.* 511).

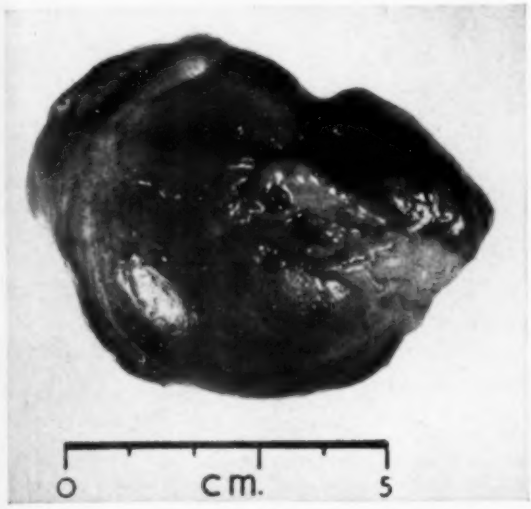

FIG. 506.—*Case* 1. One of the recurrent tumours removed at the fourth operation. It has a fairly definite capsule and is generously supplied with blood-vessels.

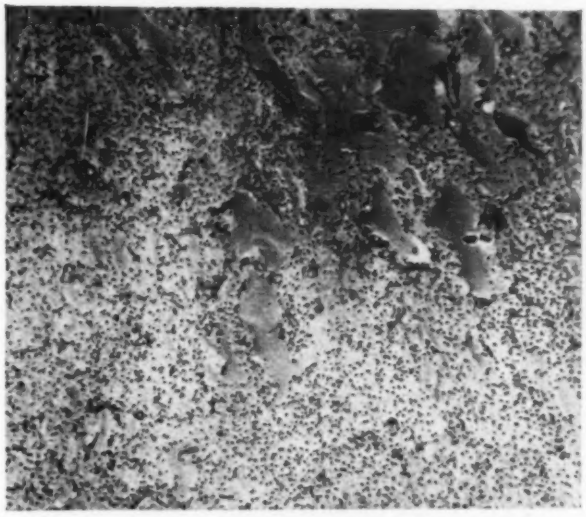

FIG. 507.—*Case* 1. Myxomatous part of tumour with mucin running together into pools. H. and E. (× 52.)

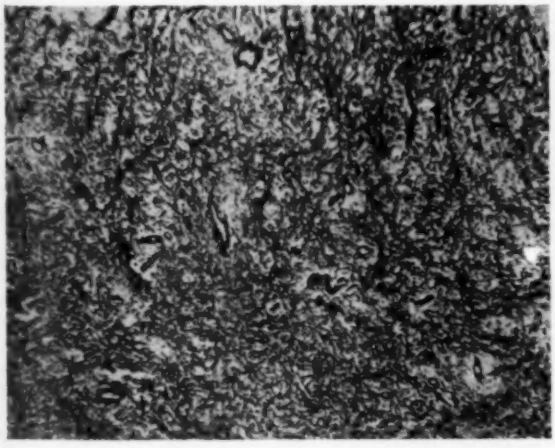

FIG. 508.—Similar part to *Fig.* 507, but impregnated with silver to show the background of tangled reticulin fibrils with a condensation of fibres around the vessels. Silver. (× 60.)

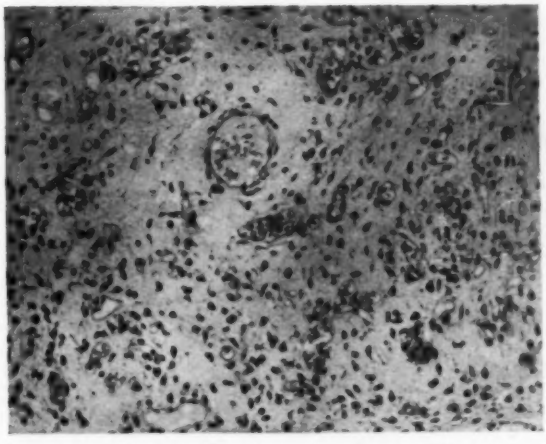

FIG. 509.—*Case* 1. Showing angiomatous proliferation of small vessels. H. and E. (× 120.)

Case 2.—H. H., 95176 (Dr. Constance Wood).

1948: While in hospital receiving treatment for menorrhagia a young married woman aged 29 years was found to have a number of pedunculated swellings on the inner aspect of the right upper thigh. These were removed and were considered at operation to be lipomatous in nature. A provisional histological diagnosis of a 'richly cellular fibroma' was made and she was referred to Hammersmith Hospital for post-operative radiation. Here the diagnosis was amended to one of mesenchymoma and in view of this report radiotherapy was considered inadvisable.

March, 1950: A small local recurrence was excised.

November, 1952: No evidence of local recurrence. We have no record of her progress since.

PATHOLOGY.—Sections of the four tumours removed in 1948 were available. All four lay immediately under the epidermis and were between 1 cm. and 2 cm. diameter. The 1950 recurrence was similar in size and position. All five tumours were essentially alike, consisting of myxomatous tissue and proliferating blood-vessels. They differed from the tumours of *Case* 1 in

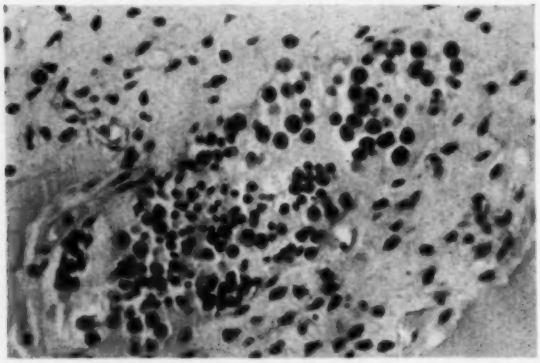

FIG. 510.—*Case* 1. Focus of hæmopoiesis. H. and E. (× 245.)

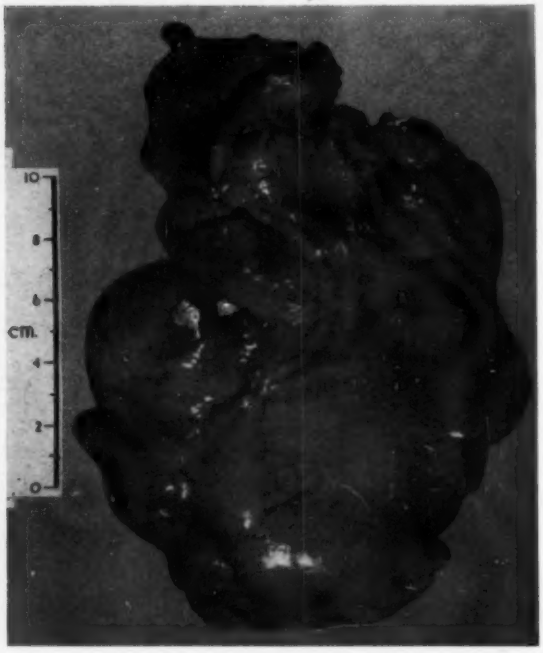

FIG. 512.—*Case* 3. The operation specimen, which was lobulated and apparently well encapsulated.

containing a higher proportion of spindle-shaped fibroblasts and more reticulin fibrils, yet the cellularity of the tumours was on average no less than that of *Case* 1. Frozen sections were not available but there were groups of cells with foamy cytoplasm resembling lipoblasts. Tissue mast cells were very frequent. Lymphocytes and plasma cells were also frequent but were presumably reactive.

Case 3.—H. H., 154994 (Mr. Ralph Shackman).

December, 1953: A woman of 70 years came to hospital complaining of a lump in the right groin which had first been noticed ten months before and had gradually increased in size since. A tentative diagnosis of femoral hernia was made and she was put on the waiting list for admission.

February, 1954: Returned complaining of disabling pain in the right knee and calf.

In the right groin was a soft, rather flattened swelling measuring 9 × 9 cm. It was not tender, although passive flexion of the hip did cause some discomfort and made the swelling less obvious. It was dull on percussion and thought to be fluid-containing, but on attempted aspiration only a few drops of blood-stained material were obtained. On staining, no abnormal cells were

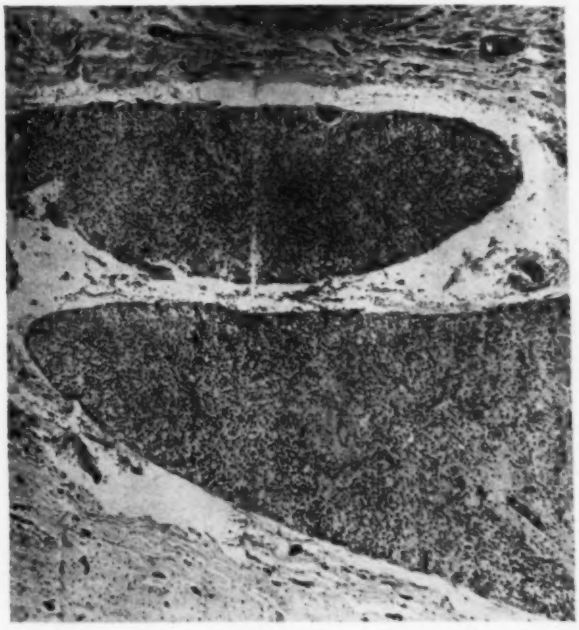

FIG. 511.—*Case* 1. Edge of tumour showing finger-like prolongations passing between connective-tissue layers. H. and E. (× 37·5.)

found. X-ray examination of the hip region was negative.

The diagnosis was now amended to one of "a benign tumour of a fatty nature" and exploration advised.

A soft, smooth, lobulated tumour was exposed in the right femoral triangle. It lay deep to pectineus, to which it was somewhat adherent. It was also tethered to the femoral sheath which was displaced laterally. As the dissection proceeded, what was believed to be a lipomatous tumour arising from the lateral aspect of obturator externus was removed without difficulty and apparently intact (*Fig.* 512).

Up to September, 1955, there was no sign of recurrence, but in December there appeared to be a poorly defined thickening in the subcutaneous tissues just proximal to the outer end of the old incision in the groin. This lump became more clearly defined and the patient was readmitted in April, 1956. At operation a lobulated fatty tumour was found deep to the adductor longus and extending between the muscle layers. The tumour and its ramifications were removed in one piece. The patient was discharged 11 days later.

PATHOLOGY.—The original tumour consisted of a lobulated smooth mass 150 × 80 × 60 mm. fairly well encapsulated, apparently lipomatous, and also containing gelatinous material.

In every part sectioned adipose fat formed the biggest single component, but this lipomatous tissue was separated by strands of loose connective-tissue spreading between the individual fat cells. This connective tissue contained stellate and spindle cells in a background of tangled reticulin fibrils and mucin. These cells were irregular in size and often hyperchromatic and mitoses were present though infrequent. Angiomatous proliferation was

present in all parts examined, though it varied in quantity. There was evidence of proliferation of the lipomatous part in the form of occasional immature fat cells. Tissue mast cells were fairly frequent. In one of the blocks at the edge of the tumour a few muscle-fibres were embedded in the loose connective tissue of the tumour. This was regarded as evidence that the latter possessed some powers of invasion.

The recurrence (1956) consisted of a lobulated mass made up of three ovoid tumours joined together by loose fibrous strands and having a poorly defined capsule covering them. The largest mass measured 100 × 60 × 40 mm., the next 35 × 30 × 40 mm., and the smallest 30 × 20 × 20 mm. The largest and the smallest had the naked-eye appearances of ordinary lipomata, but the third contained an apparent excess of grey fibrous strands traversing it. Microscopically the recurrence showed exactly the same structure as the original, and although the proportions of the fibrous and fatty components varied as noted macroscopically, the degree of variation was no more than before. In this specimen too a few muscle-fibres were included in the most superficial layers of the tumour.

FIG. 513.—*Case* 4. Pre-operative photograph showing the considerable swelling of the calf.

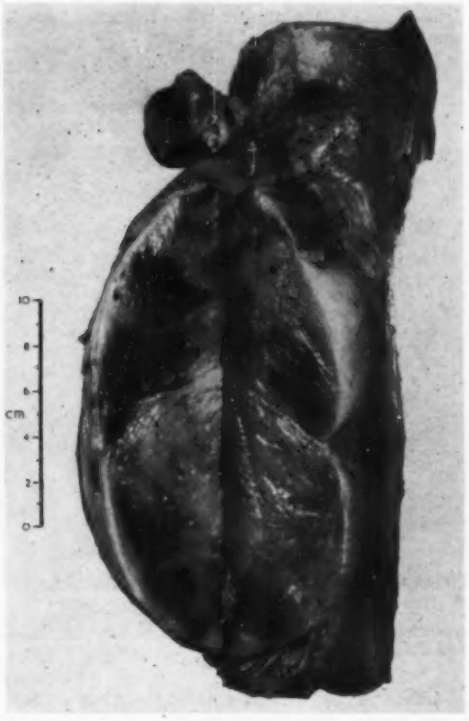

FIG. 514.—*Case* 4. Dissected amputation specimen. One of the satellite tumours (which has been split open) can be seen close to the upper pole of the main tumour mass.

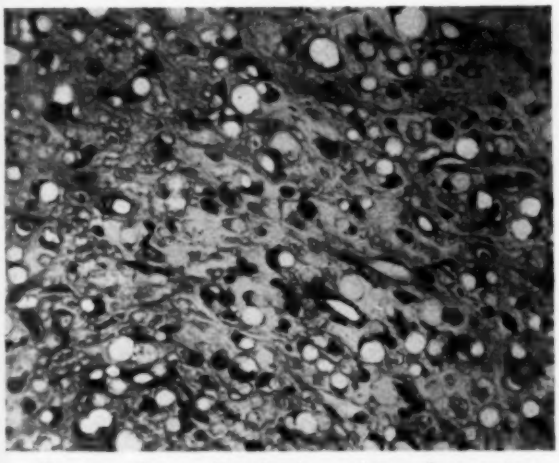

FIG. 515.—*Case* 4. Part showing a mixture of myxomatous and lipomatous elements. The fat cells resemble signet rings. H. and E. (× 325.)

FIG. 516.—*Case* 4. Tumour distending a lymphatic. H. and E. (× 15.)

Case 4.—H. H., 93470 (Professor Ian Aird).

November, 1948: A man, aged 66 years, was seen in consultation at Hammersmith Hospital complaining of a swelling of the right calf which had first been noticed about eight months previously and which had gradually increased in size since. It had, within recent weeks, caused him a considerable amount of discomfort and had made walking difficult.

The upper third of the right calf was found to be enormously swollen (*Fig.* 513). Its girth measured 52 cm. compared with 29 cm. on the opposite limb at the same level. The skin over it was stretched and was warmer than that on the other side, and there was a noticeable filling of the superficial veins. In addition there was a slight œdema of the foot.

The enlargement was found to be due to a large, soft, and smooth tumour, which did not appear to be anchored to bone and which merged into the surrounding normal

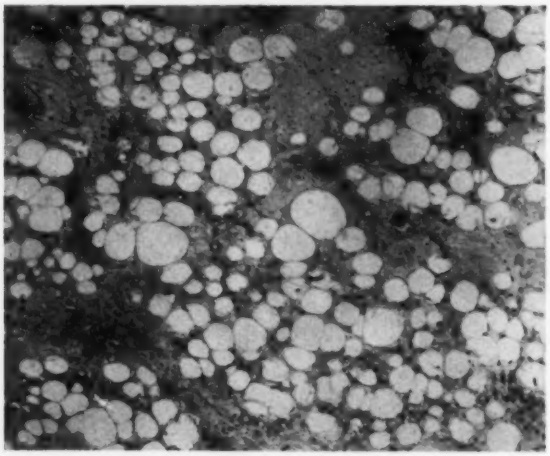

FIG. 517.—*Case* 5. A mixture of lipomatous and myxomatous tissues with considerable vascularity in the latter. H. and E. (× 43.)

tissue. Opinion was divided as to whether or not it was fluid-containing. An X-ray examination did not reveal any abnormality in the adjoining bones.

There was a nodular skin eruption on the upper part of the chest, which was diagnosed clinically as a cutaneous syphilide. The Wassermann reaction was strongly positive. In the belief that the calf swelling might be a gumma, a course of antiluetic treatment was instituted. Although the skin rash cleared noticeably the leg swelling remained unchanged, and a biopsy was considered advisable. In view of this pathological report an above-knee amputation was carried out, in February, 1949.

He made a good recovery, but died just short of 3 years later (January, 1952). An inquiry at the Registrar General's office revealed that the cause of death was certified as secondary sarcomatosis. There was however no autopsy.

PATHOLOGY.—On dissection the tumour lay in the connective-tissue plane immediately deep to the soleus. It measured 23 × 13 × 9 cm. (*Fig.* 514) and showed a trace of lobulation. It did not invade any of the muscles, nerves, or vessels, but there were three satellite tumours proximal to the main one. The largest measured 5 × 4 × 3·5 cm., and lay in the popliteal space separated from the main tumour by the plantaris muscle. Two smaller tumours, roughly rounded and 1 cm. in diameter, lay lateral to the popliteal vessels. All four tumours were pinkish-grey and gelatinous on section, with scanty strands of fibrous tissue traversing them.

Histologically all four were alike. The dominant structure is myxomatous, with stellate cells in a mucoid background. Small vessels are extremely frequent and are clearly part of the tumour. Young fat cells are present in various stages of maturity from those with small sudanophil globules up to large cells with a single globule of fat indistinguishable from an adult fat cell (*Fig.* 515). Such fat cells were uncommon. The histological structure was not significantly different from that of the other tumours and purely on the cellular appearance it was not possible to foretell the development of metastases. However, in re-investigating the case further sections of one of the small satellite tumours from the popliteal space revealed a finger-like prolongation of tumour growing into a large lymphatic (*Fig.* 516). It was possibly from such an intravascular growth that fragments broke off to metastasize.

Case 5.—H. H., 16736.

May, 1937: A man of 44 years was admitted to Salisbury General Infirmary complaining of progressive enlargement of the abdomen. Later he was submitted to operation, when large amounts of tumour material were removed from the peritoneal cavity.

September: He was given a short course of deep X-ray therapy to the abdomen, following which he was troubled by urgent vomiting.

December: Admitted to Hammersmith Hospital under the care of Professor Grey Turner. His abdomen at that time was grossly distended: it was dull on percussion and a fluid thrill was present. Four attempts were made at paracentesis, but no fluid was obtained.

January, 1938: Laparotomy. He was found to have a massive retroperitoneal tumour, which had bulged forwards displacing the viscera laterally and pushing the posterior parietal peritoneum forwards against the anterior abdominal wall. A heroic attempt was made at its removal, about 10 kg. of myxomatous material being evacuated. He died on the following day.

PATHOLOGY.—At autopsy there was an extraperitoneal tumour arising out of the pelvis. Posteriorly its highest extension reached the lower pole of the left kidney. It lined the bony pelvis as an extraperitoneal mass and anteriorly it reached the lower part of the anterior abdominal wall above the bladder. All this part had the naked-eye characters of a lipoma. At about the lumbo-sacral junction the tumour had erupted into the peritoneal cavity and the bulk of the intraperitoneal mass had been removed surgically. The stump left, which resembled the excised mass, was of pink gelatinous appearance and in the hollow of the sacrum it blended with the remaining lipoma, suggesting that both were parts of one tumour. There were no separate tumours or metastases.

Histology.—

Gelatinous part: The background structure in all blocks is that of a myxoma, but this varies in its cellular activity from that of a quite benign looking myxoma to one suggesting a myxosarcoma. In different parts there were foci of proliferation of small vessels giving an angiomatous structure, and in other parts there were primitive fat cells with their globules of fat giving them a mulberry-like appearance. Fibroblasts were present usually confined to fibrous septa.

Fatty part: In the parts sectioned the fatty tissue does not differ from an ordinary lipoma. At the junction of the fatty and the gelatinous parts the fatty lobules remain unaltered, but the fibrous strands between them are infiltrated by the myxomatous tumour (*Fig.* 517).

CLINICAL FEATURES

The tumour would appear to be one of adult life; certainly, we have no record of any occurring in childhood.

Like most primary tumours of connective tissue, it seems most often to affect the lower extremity, the thigh or buttock being especially common sites.

The first symptom is commonly the appearance of a swelling which slowly increases in size over a matter of many months or even years. It remains for a long time painless. The swelling lies deep to the skin, which may be stretched over its surface: it is, however, anchored to the deeper tissues, from which it seems to take origin. It is smooth, rounded, firm, lobulated, and painless. It is often believed

to be cystic, but the needle exploration which follows yields no fluid.

The clinical diagnosis is often that of a benign cyst, such as a semimembranous or other bursa. One of our cases was first thought to be a cold abscess. After a negative needle aspiration this may be amended to a lipoma or a fibrolipoma. The impression is in most instances one of a perfectly benign tumour which it is reasonable to hope that one will be able to enucleate readily in its entirety with every guarantee of complete cure. The diagnosis of sarcoma is likely to suggest itself only when the tumour is very large.

A radiograph will show only the presence of a soft-tissue tumour.

At operation the tumour is found to consist of curiously soft, reddish-white gelatinous material, broken up by fine septa into numerous lobulations. It may seem sometimes to be well encapsulated and to be delivered by an easy finger dissection: more often, however, it is ill-defined and extends widely in the muscle planes. In recurrent tumours, very many collections of gelatinous material may be found widely dispersed in the subcutaneous tissue as well as in the subjacent muscles.

TREATMENT

If during the course of a local excision of a mesenchymoma there is spillage of its mucoid content into the wound, whether it be from an ill-judged cut or from rough handling, local recurrence must be almost inevitable: but even when the tumour is cleanly exposed and removed intact by a careful and patient dissection, the surgeon is all too often dismayed by the reappearance of the tumour at the operation site. Local recurrence after attempted excision is one of the most distinctive clinical features of this tumour. The reason for our failure is made all too evident by the dissection of the amputated leg in *Case* 4. It will obviously be a matter of the very greatest technical difficulty to detect and to follow out and excise every single one of the discontinuous gelatinous processes which can be seen to spread outwards from the main body of the tumours into the adjacent muscle and fascia. Furthermore, there are often microscopical extensions beyond the naked-eye limits (*Case* 1).

Since in our view treatment will necessarily imply a wide sacrifice to tissue, it is first essential to establish the diagnosis beyond dispute. When at an exploratory operation we are confronted by a gelatinous tumour of this sort, a biopsy must first be taken, preferably the complete excision of an outlying lobule of the main tumour mass. If the luxury of a frozen section and a sound pathological opinion is not immediately available, we must close the wound and await the report from examination of a paraffin section. In any case, the technical difficulties of cutting good frozen sections of this tumour are so great and the diagnosis is so important that paraffin sections are still preferable.

1. If the tumour is on an extremity at a level where it can most adequately be excised by amputation, this will be the treatment of choice. This would be advised for any lesion below the upper third of the thigh or upper arm. Although the decision to amputate in the case of the upper extremity is a hard one to make, sacrifice of even a right-hand member would in the light of experience seem to be justified. For a tumour in the buttock or groin, only a hindquarter amputation is likely to fit the bill, but even in a young and fit patient few would contemplate such a mutilating procedure. There should, however, be not the slightest hesitation in practising the most extensive local removal of muscle and fascia no matter how serious the resulting functional handicap may be.

2. If the tumour is on the trunk, the widest possible excision of the muscles involved should be carried out, extending the limit of the operation to what may seem to the uninitiated a quite unjustifiably long way beyond the edge of the tumour as estimated by the naked eye, and with a ruthless disregard for the retention of muscles, however important their function.

3. The appearance of a recurrence should, if the position of the tumour allows, always be made the signal for an amputation: this operation can to an unwilling patient now be pleaded with more urgency and insistence. When amputation is impossible, there is no alternative to wide excision, repeated just as often as is necessary, and so long as it remains feasible. It is in cases of this sort that hindquarter amputation alone holds out any prospect of cure.

As in the management of so many forms of cancer, it is at the time of the first treatment that we have the best chance of cure: every succeeding local recurrence diminishes the expectation of ultimate success.

4. There is little evidence that radiotherapy in any form can lessen the risk of local recurrence or can favourably affect the natural history of the tumour. It is none the less often the practice to irradiate the operation after local excision, or the extensive recurrence in the inoperable case.

HISTOLOGY

In the 5 cases reported and in a number of other cases of which we have seen the histology in consultation, the structure has been remarkably constant. There has been a mixture of three connective-tissue components: myxomatous, angiomatous, and fatty. In most cases the myxomatous portion has been the dominant one and has given the tumour its naked-eye characteristics, but sometimes, as in *Case* 3, there has been a sufficient mingling with formed adipose tissue to alter the appearance to one suggesting a lipoma, and in *Case* 5 there was a large, purely lipomatous component. The second most striking part is the angiomatous one. The number of vessels is vastly in excess of the need of the tissue, they are irregular in size and pattern, and can be seen to be proliferating. The concentration of vessels is usually sufficient to give a reddish tint to the tumour, which contrasts with the pearly white of a pure myxoma. The fatty element is more variable in quantity. In 2 cases (*Cases* 3 and 5) it formed a considerable part of the tumour and had the structure of a fully differentiated lipoma, but careful search in all cases revealed cells with the cytological characters of young fat cells, implying that the tumour cells retained the power of differentiating into fat cells even if there was no obviously lipomatous component. Fibrous tissue was, of

course, an essential component. Strands of collagen formed the septa and often surrounded vessels but did not form a capsule save by compression. Throughout the bulk of the tumour fine or coarse reticulin formed the only fibre present. This reticulin formed a tangle of fibres, fairly dense and evenly distributed, and gave the tumour its solidity. In silver preparations the fibre was generally intermediate between the fine black fibres of reticulin proper and the coarse brown fibres of fully formed collagen.

The tumours are relatively cellular. The myxomatous part has spindle and stellate cells in greater concentration than a pure myxoma and there is a certain variability of cell size, but bizarre cells and mitotic figures are rare. In *Cases* 1 and 4 the mucin tended to run together to form pools and, when large, these compressed the tissue at their edges and gave the impression of formed spaces. We were not able to confirm Gilmour's view that the tumour formed spaces lined by endothelium. The angiomatous cells are not easily distinguished and can only be safely recognized when they form vascular channels. Tissue mast cells are usually frequent and since they often stain pink with eosin, can fail to be recognized unless examined carefully. If the mucin is stained metachromatically by such dyes as toluidine blue the mast cells stain deeply and metachromatically, whilst if alcian blue is used, and we have found it the most sensitive stain, a neutral-red counterstain shows up the mast cells clearly. Lymphocytes and macrophages are seen in most cases, but they are scanty and since they could be of inflammatory origin there is no justification for assuming that they are part of the tumour, although we did find a single focus of hæmopoiesis in *Case* 1.

It is difficult to assess the frequency of this type of tumour because it does not appear to be sufficiently well recognized as an entity. Apart from the cases of Gilmour (1943), of Symmers and Nangle (1951), and of Pemberton and Cromack (1953) already mentioned, Sponsel, McDonald, and Ghormley (1952), under the name of 'myxosarcoma', refer to 9 cases that appear to include at least some like ours. Of these, 4 recurred once or more after excision and 3 further cases developed metastases. Jaffe (1926), under the title of 'lipoma pseudomyxomatosis', described 1 recurrent tumour of the groin which appears to have been similar to our cases. De Grailly, Leger, and Birabeu (1952) have described an interesting series of recurrent tumours of mesenchymatous origin. After describing the tumour under the title of the dominant component as recurrent fibroma, lipoma, or myxoma, they point out that all of them contain more than one component and have an embryonic appearance, and they suggest that they might be grouped together as mesenchymomas. They have stressed a point which we think is important and not sufficiently appreciated, namely, that in all these tumours the vessels are not merely a stromal reaction for the nourishment of the tissue but an actively growing part of the tumour. This angioblastic proliferation we have found to be a constant and striking feature and one that separates these tumours immediately from the benign myxoma.

COMMENTARY

There may be some who feel that any attempt to separate off this tumour from the general group of malignant tumours of the connective tissue is both unnecessary and unreasonable. Cade, in his Presidential Address to the Section of Surgery at the Royal Society of Medicine, when he reviewed a very large personal series of malignant tumours of the soft parts, made no separate mention of it. It may be that he encountered no single example in his experience: alternatively, he would classify such cases as we are here reporting with the myxo- or myxo-lipo- or myxo-lipo-angio- variant of the main sarcoma group.

Our justification for considering this tumour as an entity deserving separate consideration we have already set out in the preamble to this communication. It is, however, perhaps allowable to reiterate that when in the course of surgical practice we encounter a connective-tissue tumour with the clinical features which we have described, one should bear in mind the possibilities of its sinister development. This is true, however benign its clinical appearance and however innocent-looking at exploration are its gelatinous collections. We should in no way allow any misgivings to be put at rest by a reassuring report from our pathologist, unless we are sure that he is fully aware of the disturbing natural course which such tumours seem often to follow.

It is a tumour given to repeated local recurrence and merits at the outset radical treatment which its appearance seems often so little to deserve.

We admit that one of our cases apparently developed blood-borne metastases but we do not consider that this spoils our case for acceptance of mesenchymoma as a separate entity.

There might also be a quarrel with the name 'mesenchymoma', especially since this term has been used in a slightly different sense in different communications. It has, however, the merit of giving a hint of the primitive nature of its structure. Further, the name has now been widely enough used in the sense in which we are continuing it to justify its retention in this context.

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EXPERIMENTAL SURGERY

AN EXPERIMENTAL STUDY OF SIALOGRAPHY, AND ITS CORRELATION WITH HISTOLOGICAL APPEARANCES, IN NORMAL PAROTID AND SUBMANDIBULAR GLANDS

By I. RANGER

FROM THE BLAND-SUTTON INSTITUTE OF PATHOLOGY, MIDDLESEX HOSPITAL

SIALOGRAPHY has now been used for many years in the study of diseases of the salivary glands, particularly the parotid (Payne, 1931), the radio-opaque medium used being originally lipiodol and more recently neo-hydriol. Its principal value has been in the investigation of obscure cases of parotitis, when a typical picture of what has been termed 'sialectasis' is often obtained (*Fig.* 518). It has recently been shown, however, by combined radiological and histological studies (Thackray, 1955; Patey and Thackray, 1955) that the globules seen radiologically are not, as had been previously thought, acinar or ductal dilatations, but extravasations of the medium into the substance of the gland. It was thought that a similar combined study of normal glands, with controlled amounts of injection medium, might be of value in throwing light on the mechanism of the sialectatic process.

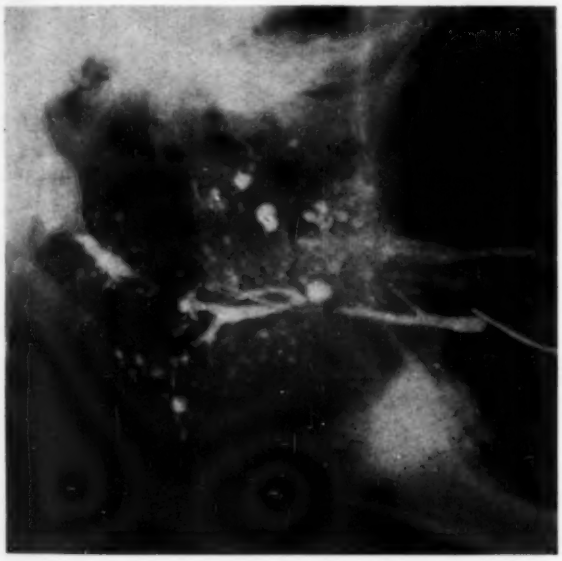


FIG. 518.—Sialogram showing the globular 'sialectatic' picture associated with chronic parotitis. It is seen that the globules are present throughout the gland and have resulted from rupture of numerous intralobular ducts.

METHOD OF STUDY

Forty glands taken from post-mortem-room subjects were examined, 20 parotid and 20 submandibular. Radiographic pictures were obtained as described below and subsequent histological studies were made of selected glands to correlate the radiographic and histological appearances. Only glands were excised which had been symptomless in life and care was taken to remove them with their capsule intact. In the case of the parotid gland this necessitated excising the superficial part of the masseter muscle, a portion of the external auditory meatus, and the investing fascia of the neck, where it splits to ensheath the sternomastoid muscle. In the submandibular gland the superficial portion was dissected first, after which the mylohyoid muscle was divided and the deep portion of the gland with its main duct was removed. It was often found necessary to remove a portion of the sublingual gland in order to excise the main duct completely.

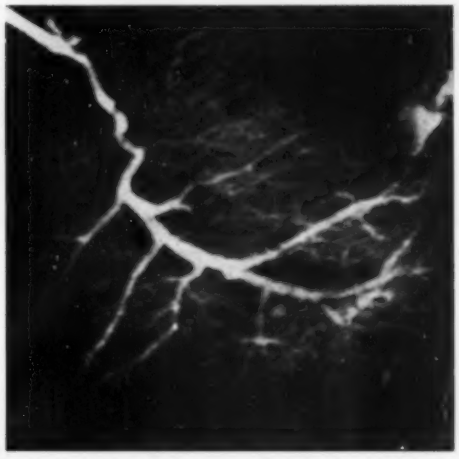


FIG. 519.—Parotid sialogram following the injection of 0·5 ml. of contrast medium. The main duct and its interlobular and intralobular branches are clearly seen.

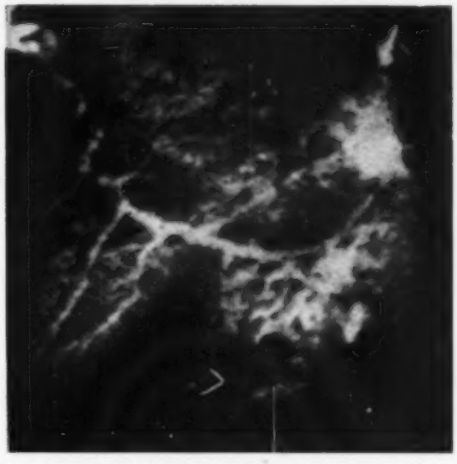


FIG. 520.—Parotid gland as shown in *Fig.* 519 after 2 ml. had been injected. The mottling of the gland, which tends to obscure the duct pattern, is due to acinar filling.

A round blunt-ended No. 20 needle was inserted into the main duct orifice and neo-hydriol injected very slowly, radiographs being taken after 0·5, 1, 1·5, and 2 ml. had been injected. In 5 submandibular glands the quantity was increased to 5 ml. The glands were then fixed in formalin and sections made for histological examination from different areas of the selected glands.

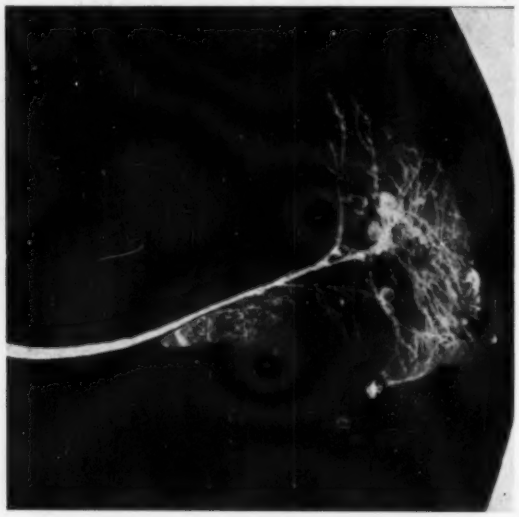


FIG. 521.—Sialogram of the parotid gland using 0·5 ml. of contrast medium, which shows the outline of the main ducts and, in addition, small globular opacities in the substance of the gland.

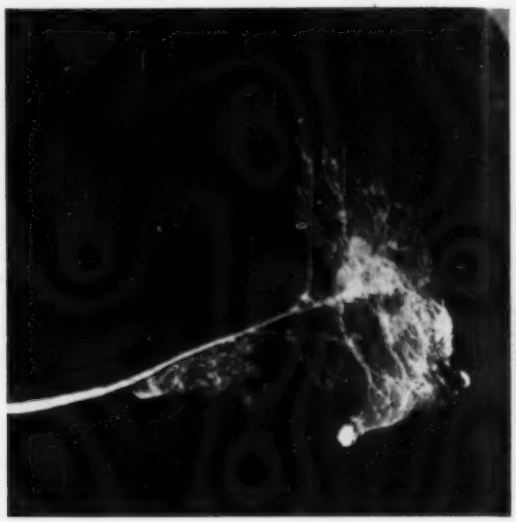
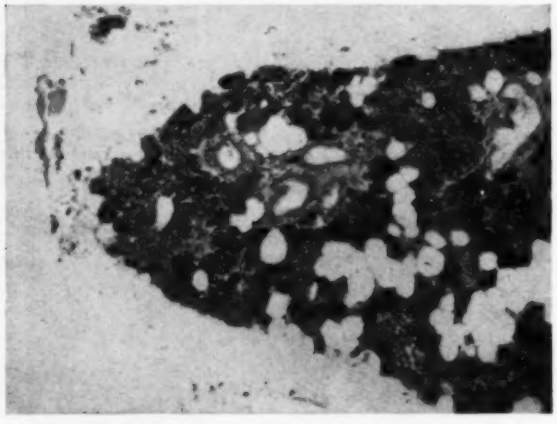


FIG. 522.—The same parotid gland as in *Fig.* 521 after 2 ml. of medium had been used. The globular opacities are more numerous and the original ones have increased in size. It is seen that the majority of the ducts appear unaffected.



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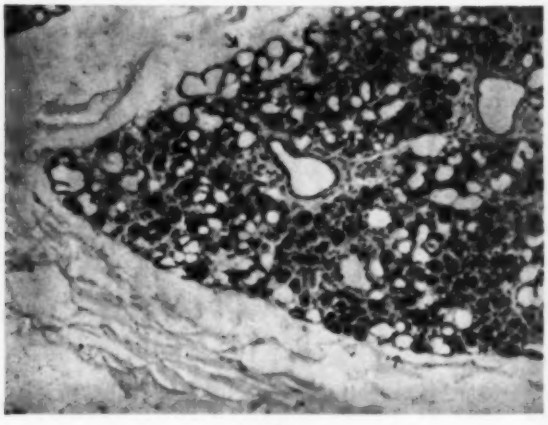

B

FIG. 523.—A, Section of a normal parotid gland. The intralobular ducts are clearly seen. The acini are solid rings of darkly staining cells, the central lumen being a potential space only. The clear areas represent normal adipose tissue cells. B, Section of a parotid gland after injection of contrast medium. The intralobular ducts are distended and some of the acini (as indicated by the arrow) are grossly dilated, the epithelial cells forming a flattened rim at the periphery. Note the acinar filling is patchy, many areas appearing normal.

RESULTS

Parotid Glands.—The radiographs could be divided into two distinct groups. In the first, containing 7 out of the 20 glands, the duct system was clearly seen when 0·5 ml. had been injected, and the parenchyma of the gland appeared as a soft-tissue shadow (*Fig.* 519). Increasing quantities showed a diffuse mottling in the gland which, when 2 ml. had been injected, obscured the clear outline of the ducts (*Fig.* 520).

The remaining 13 glands showed, in addition to the ducts, small globular opacities in close proximity to the main ducts. These were few in number and much of the gland appeared unaffected (*Fig.* 521). With larger volumes more globular opacities were seen and the original ones had increased in size. Again, the patchy mottling of the gland was noticed with the increased volume (*Fig.* 522). Though the individual globules appeared similar to those seen in the ' sialectatic ' picture, the general distribution was different, as only a few areas appeared affected while the remainder appeared relatively normal.

Histological sections of the first group of injected glands showed most change in the acini. These were distended, the degree varying from area to area (*Fig.* 523, A, B). The acini, which in the normal gland are collapsed and in which there is only a potential space, were distended so that the acinar cells were compressed to a rim at the periphery.

The main ducts with the interlobular and intralobular branches were distended but otherwise normal. The mottling is therefore due to acinar filling, patchy in distribution.

In the second group of 13 cases, in addition to the patchy acinar filling and duct distension, there was extravasation of the medium into the substance of the glands. This was found to have occurred

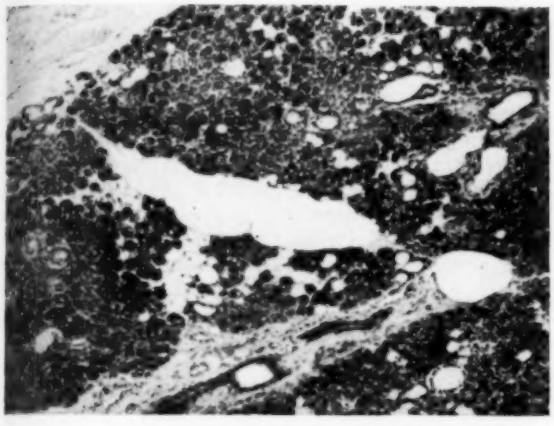

FIG. 524.—Section of a parotid gland which showed a globular pattern on sialography. The ducts are distended, and clear spaces without cell outline can be seen in the substance of the gland. As explained in the text, this is due to rupture of the intralobular ducts with extravasation of the medium into the substance of the gland.

FIG. 526.—Sialogram of the same gland as in *Fig.* 525 after 2 ml. of medium had been injected. The duct pattern is largely obscured by acinar filling.

through the intralobular ducts, the areas corresponding in shape, size, and position to those seen on the radiograph (*Fig.* 524). Many of the intralobular ducts appeared normal so that the rupture was of individual ducts rather than a diffuse change in all the ducts.

Submandibular Glands.—Using the same method as with the parotid glands, the radiological features of all 20 glands were the same. With small quantities the main ducts were seen and there was in addition a faint mottling (*Fig.* 525), which became rapidly more apparent until at 2 ml. the mottling tended to obscure the duct pattern (*Fig.* 526). In none of the glands was there any radiological evidence of a ' sialectatic ' pattern. In the 5 cases when 5 ml. was injected, the duct pattern was not seen at all

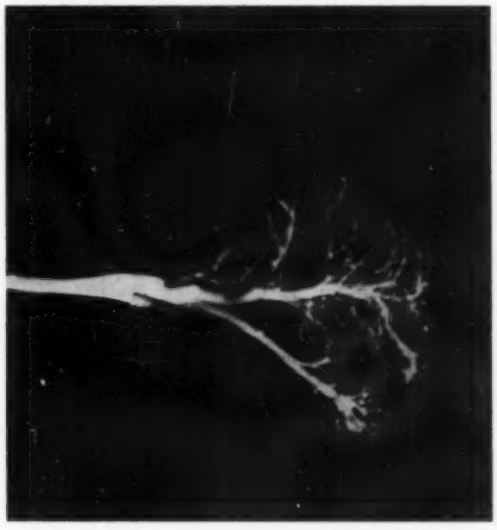

FIG. 525.—Sialogram of the submandibular gland, with 0·5 ml. of medium. It shows a complete duct pattern and in addition there is a faint mottling of the gland due to early acinar filling.

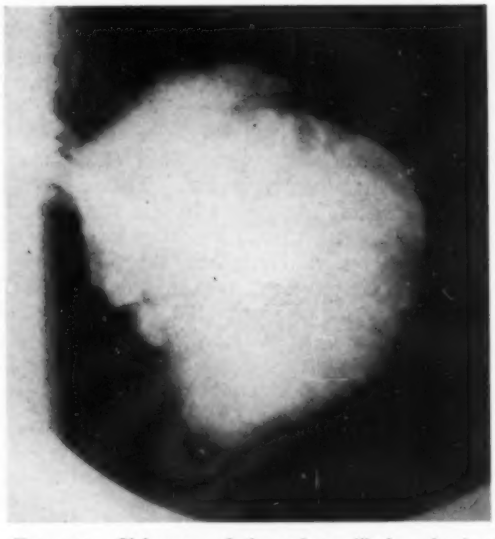

FIG. 527.—Sialogram of the submandibular gland with 5 ml. of medium. The gross overdistension of the acini completely obscures the duct pattern. In none of the submandibular glands examined was there evidence of extravasation of the medium through the intralobular ducts.

because of the gross opacity of the parenchyma of the gland (*Fig.* 527).

Histological sections from these glands showed dilatations of the ducts and gross distension of the acini (*Fig.* 527). In none of the sections examined was there evidence of duct rupture. The study of numerous sections failed to reveal any structural difference between the ducts of the submandibular and parotid gland, except that the intralobular ducts of the submandibular are shorter and wider than those of the parotid.

DISCUSSION

The diffuse opacity of the parenchyma of the salivary gland on sialography is well known, and the term ' sialo-acinar reflux ' (Samuel, 1950) was coined to describe it. In this series it has been shown that this opacity, which has a patchy and mottled appearance, is on histological section due to irregular distension of the acini. It has been referred to simply as ' acinar filling '. It was found in all 40 glands examined. Increasing quantities of media injected produced distension of more acini, with the result that the gland as a whole became opaque. This effect was seen more readily and with smaller quantities in the submandibular than in the parotid gland.

In none of the submandibular glands was there radiological or histological evidence of rupture of the ducts. In the series of normal parotid glands, on the other hand, extravasation of the medium through the intralobular ducts was seen in 13 of the 20 glands. In the parotid, although the individual ' globule ' was similar to that seen in chronic ' sialectatic ' parotitis, rupture only occurred through a few ducts, the majority remaining intact. The picture therefore differs from that seen in chronic parotitis in which the ' sialectatic ' picture is diffuse, and the inference can be drawn that in that disease there would appear to be a factor making the intralobular ducts as a whole more liable to rupture. In the normal glands, as in chronic parotitis, when rupture occurs, it does so before acinar filling is apparent.

The different response of the two types of salivary glands may be due to the fact that the intralobular ducts of the submandibular gland are shorter and wider than those of the parotid. This would therefore allow the injected media to distend the potentially large acinar space easily and cause less hold up in the intralobular ducts. This also explains the earlier acinar filling noted in the submandibular gland and makes rupture of its ducts less likely.

In this series a complete duct pattern was obtained when only 0·5 ml. was injected, and further amounts tended to obscure this pattern by acinar filling, and in the case of the parotid gland by duct rupture also. It would seem from this study of 40 normal salivary glands that sialography using a larger quantity should only be used exceptionally and with caution in clinical practice.

SUMMARY

1. Sialograms were performed on 40 normal parotid and submandibular glands removed at post-mortem examination, using graded amounts of neo-hydriol, and correlated with histological appearances.

2. In 13 of the 20 parotid glands evidence of rupture of some of the intralobular ducts was seen with extravasation of the medium into the substance of the gland. This differed from that seen in chronic parotitis, in that although the individual lesions appeared the same, they were confined to a minority of the ducts rather than being more generalized as in that disease.

3. When duct rupture did occur it did so before acinar filling was apparent.

4. In none of the 20 submandibular glands was duct rupture seen. This is thought to be due to the fact that the intralobular ducts of the submandibular gland are shorter and wider than those of the parotid gland.

5. A complete duct pattern was seen in all cases when 0·5 ml. of neo-hydriol was injected. Further increase in quantity tended to obscure the pattern by acinar filling and in the case of the parotid duct by rupture also.

6. It is therefore concluded that sialography using larger quantities should not be carried out unless there is evidence that the duct capacity is greater than the normal.

I should like to acknowledge the help of Mr. D. H. Patey in the preparation of this paper ; of Dr. A. C. Thackray, who also prepared the microphotography ; of Dr. J. N. Pattinson and the staff of the X-ray Diagnostic Department ; and of Mr. M. Turney, of the Photographic Department, who reproduced the X-ray plates.

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THE EFFECT OF HYPOTHERMIA ON ACUTE CORONARY OCCLUSION

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DEPARTMENTS OF SURGERY AND VETERINARY SURGERY OF THE UNIVERSITY OF GLASGOW

The treatment of myocardial infarction from coronary arterial occlusion has undergone little change since the recognition of the condition. The basis of present treatment is lowering the work of the heart by rest together with anticoagulant drugs. Any method of reducing the work of the heart without jeopardizing its blood-supply is therefore worthy of investigation since the mortality from coronary arterial occlusion remains high.

The feasibility of using body cooling to lower the metabolic rate was demonstrated by Fay (1940) and the method has been extensively employed, especially for cardiac and brain surgery. It has been shown by Bigelow, Lindsay, Harrison, Gordon, and Greenwood (1950) that there is no increased oxygen demand during rewarming, suggesting that no tissue anoxia occurs during the hypothermic phase. Edwards, Tulny, Reber, Siegel, and Bing (1954) and Sabiston, Thielen, and Gregg (1955) have shown that in dogs at 26° C. body temperature, the cardiac output is reduced to a third of its level at normal body temperature while the coronary blood-flow is halved. It would appear possible, therefore, to try to lighten the load on the heart in cases of coronary arterial occlusion by lowering the body temperature. Further, at such lowered temperatures the blood does not clot so readily.

THE INVESTIGATION

To test this out, acute ischæmia of the myocardium was produced by ligation of the circumflex branch of the left coronary artery in 10 normothermic and 10 hypothermic dogs.

Methods.—Healthy mongrel dogs of body-weight 15–20 kg. were anæsthetized with intravenous sodium pentobarbital, 20–30 mg. per kg. body-weight. The trachea was intubated with a cuffed tube and connected to a closed-circuit anæsthetic machine delivering oxygen and fitted with a carbon-dioxide absorber. A carbon-dioxide meter was connected to the expiratory side of the circuit and the level of respiration adjusted to give a reading of 1–2 per cent throughout the duration of the experiment.

Rectal temperature and heart-rate were recorded at 5-minute intervals. Surface cooling of the animal was effected by addition of crushed ice to a water-filled bath in which the body was immersed. When the rectal temperature reached 28° C. cooling was stopped. The chest was opened through a left lateral incision in the fourth interspace. The pericardium was opened anterior to the phrenic nerve and a ligature was placed around the circumflex branch of the left coronary artery, 0·5 cm. from its origin, tied, and the chest closed.

Electrocardiographic tracings were made of the three standard limb leads immediately after induction of anæsthesia, after cooling, after thoracotomy, and at 2-minute intervals after ligation of the artery. Blood samples were withdrawn in heparinized, paraffin-coated syringes from the aorta and the coronary sinus immediately after the chest was opened. The oxygen content of these samples was determined by the manometric method of Van Slyke and Neill. After death, a fine barium sulphate emulsion was injected into the ligated artery and the heart radiographed.

The normothermic group were treated in identical fashion with omission of cooling. In both groups the time occupied in opening the chest and ligating the artery did not exceed 10 minutes.

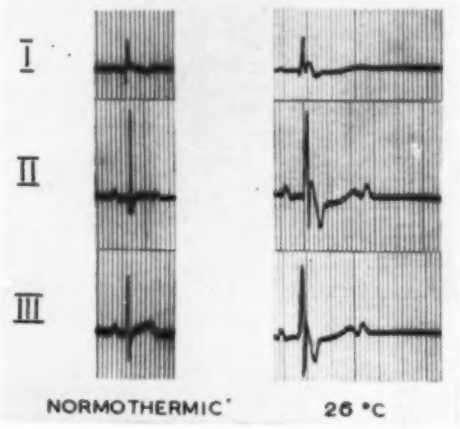

Fig. 528.—E.C.G. (standard leads) in a normothermic dog and later after reducing the body temperatue to 26° C., showing RR¹ and T-wave distortion.

Results.—Cooling took on the average 1¼ hours. The rectal temperature after thoracotomy was 26°–27° C., while the heart-rate was about half that at normothermic levels. The X-ray studies showed a fairly constant pattern of distribution of the tied circumflex artery. Following a practice previously adopted (Smith, Demming, Eleff, and Eckstein, 1952), the mortality rate for the hour following the arterial ligation was taken and the survival time in minutes within this period was noted. Within the hour 70 per cent of the normothermic dogs died of ventricular fibrillation while 100 per cent of the hypothermic animals died from the same cause. The survival time for the 70 per cent of normothermic animals dying within the hour was: mean time 38·5 min. (range 5–59 min.); and for the 100 per cent hypothermic animals: mean time 5·7 min. (range 2–10·5 min.).

Blood Gas Studies (vol. of oxygen per 100 ml. blood).—

	Mean Values		
	Coronary Artery	*Coronary Sinus*	*A–V Difference*
Normothermic	16·8	4·3	12·1
Hypothermic	17·2	7·4	9·2

DISCUSSION

Since a fairly constant distribution pattern was found for the occluded circumflex artery, the volume of myocardium deprived of blood must have been uniform throughout both groups. The length of

time for which any one heart beats before the onset of ventricular fibrillation must therefore depend on the presence and the size of the anastomotic vessels between the area deprived of blood and the adjacent normally supplied myocardium. The shorter time of survival of the cooled group may be due to imperfect opening up of intercoronary anastomoses. If, on the other hand, these channels are adequate, then the blood-supply to the hypothermic heart cells. This is suggested by the regular appearance of RR[1] waves and T-wave distortions which appear during the process of cooling (*Fig.* 528). These are quite distinct from the electrocardiographic changes due to myocardial anoxia from circumflex arterial occlusion in both groups of animals (*Fig.* 529). This suggestion receives some support from the observations of Swann, Zeavin, Holmes, and Montgomery (1953) that the serum-potassium levels

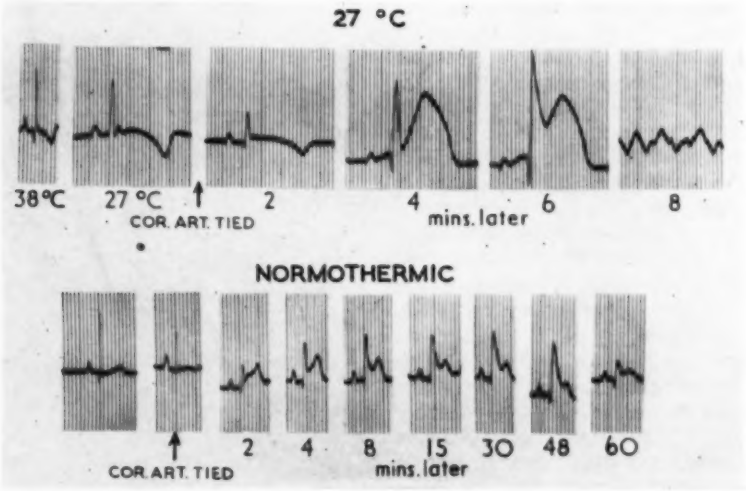

FIG. 529.—E.C.G. (lead II) to show changes following left circumflex coronary artery ligation. Upper trace shows onset of ventricular fibrillation at 8 min., animal at 27° C. body temperature. Lower trace is from a normothermic animal surviving the 1-hour test period.

before coronary occlusion may be so poor that enough blood is not available to pass into them.

With regard to the adequacy of the blood-supply of the cooled heart, the arteriovenous oxygen difference is less in the hypothermic group by virtue of the fact that the oxygen content of the coronary sinus blood is higher than in the normothermic group. This might be simply an indication of adequacy of coronary blood-flow with adequate oxygenation of the myocardium, since any tendency to anoxia might be expected to give lower levels of oxygen in the coronary sinus blood. On the other hand, it might be a manifestation of alteration of the dissociation curve of hæmoglobin due to the low temperature. This was investigated on an animal, not in the series, cooled to 26° C. The oxygen supplied to the animal was cut down until the oxygen saturation of the coronary arterial blood was 80 per cent (12·7 vol. per cent). The oxygen extraction of the heart was maintained (9·8 vol. per cent) and the coronary sinus blood-oxygen level fell to 19 per cent saturation (2·9 vol. per cent). From this it appears that the blood-supply to the heart and the oxygen extraction by the myocardium continues satisfactorily at 26° C.

An alternative explanation of the susceptibility of the cooled heart to ventricular fibrillation may lie not in the opening of intercoronary anastomoses but in some change in the conducting mechanism of the heart or the polarization process of the myocardial fall during hypothermia and that ventricular fibrillation occurring in the hypothermic dog's heart can be halted and normal rhythm restored by the intracoronary injection of potassium salts.

CONCLUSIONS

Simple body-surface cooling as a means of lowering the metabolism of the body and the heart appears to have no place in the treatment of acute coronary arterial occlusion. More important, perhaps, is the indication that the use of this technique as an ancillary method in anæsthesia for the 'poor risk' patient is likely to be fraught with danger, particularly if coronary arterial insufficiency already exists, whether from organic changes in the coronary arterial tree or from diminished filling due to hæmorrhage or shock.

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THE EFFECT OF ENDOCRINE ABLATION ON THE HEALING OF INCISED WOUNDS IN APONEUROSIS

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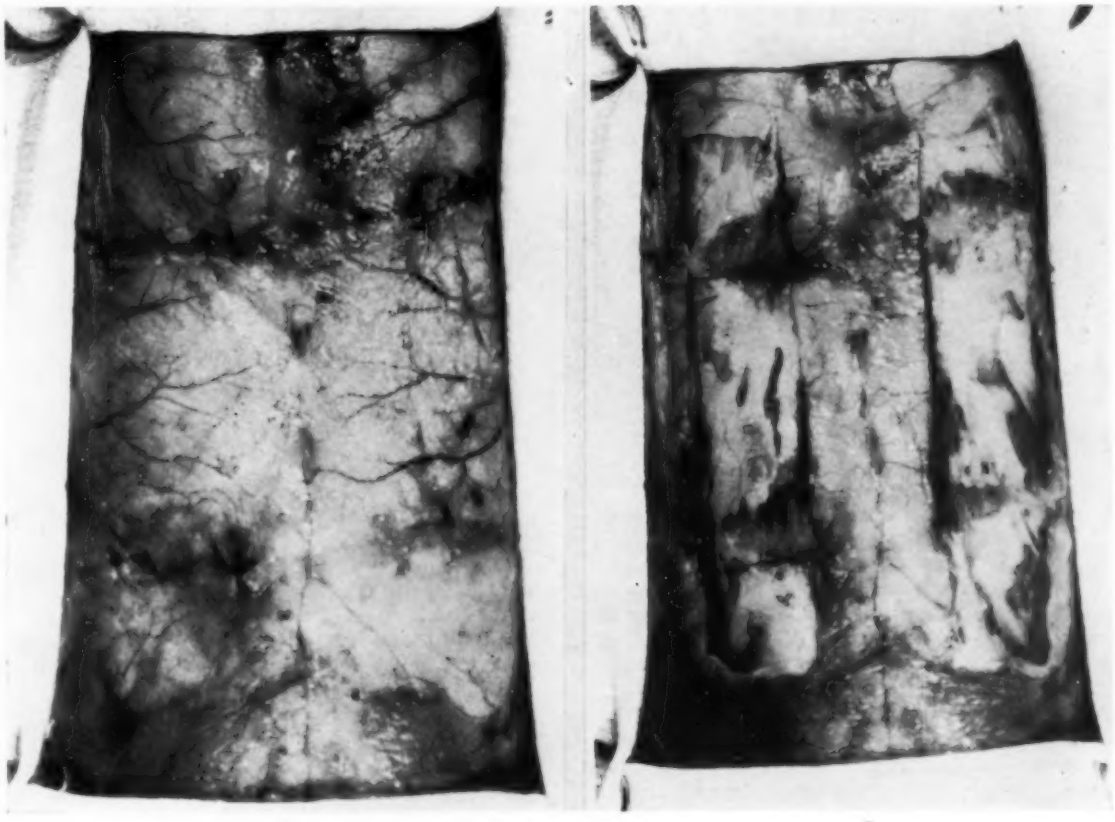
In a previous study (Douglas, 1952) it was observed that the healing of incised wounds in the lumbodorsal aponeurosis of rabbits followed a regular pattern in which two features were prominent :—

1. The curve of gain of tensile strength is exponential in form and in two independent sets of data was very similar.



A B

Fig. 530.— Lumbodorsal aponeurosis of rabbit. A, With sutured wounds in left side ; B, After excision of 2 cm. strip from each side.

2. The wound remains weaker than the parent tissue for at least three months and, as a rule, does not regain its original strength even after one year.

The constancy of these findings suggested that the process was systemically controlled and attempts have now been made to investigate the role of the endocrine glands.

METHODS

Adult rabbits were divided into five groups : Groups 1, 2, and 3 were submitted to hypophysectomy, bilateral adrenalectomy, and thyroidectomy respectively ; Group 4 was used as a control group ; and Group 5 was submitted to nephrectomy to provide operative trauma comparable to adrenalectomy, but not being associated as far as is known with hormone deprivation.

It was originally intended to have 20 animals in each group, but because of the high mortality of hypophysectomy and of adrenalectomy, we had to be content with 15 and 11 animals in these groups respectively.

Hypophysectomy was carried out by the parapharyngeal technique of Jacobsohn and Westman (1940) and proved to be a most lethal operation, a large number of rabbits being submitted to the operation to obtain the 15 survivors. Most of the deaths were due to respiratory obstruction from blood leaking into the posterior nares. Other deaths were due to hypoglycæmia during the first 24 hours, even though the animals were given 20 ml. of 5 per cent dextrose in water subcutaneously after operation. The completeness of the hypophysectomy was checked by post-mortem examination.

Adrenalectomy was carried out by a two-stage lumbar approach. Because of the intimate relationship of the right adrenal to the vena cava it was found quite impossible to remove the right adrenal by ordinary dissection. An attempt was made to overcome this by resecting a segment of the vena

cava and the ipsilateral kidney, but this proved invariably fatal. A special technique was therefore evolved. The adrenal was gradually scooped away with a diathermy loop and the small nodule which remained on the cava was carefully fulgurated. The adequacy of the adrenalectomy was checked at post-mortem and not infrequently a small nodule of adrenal remained. This necessitated discarding the data from such animals. The adrenalectomized animals were given a weekly injection of 7·5 mg. of D.O.C.A. in almond oil. The mortality of this operation was also very high.

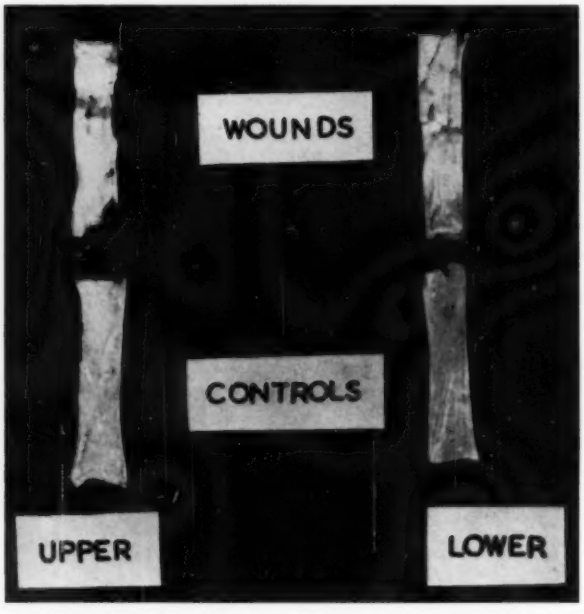


FIG. 531.—The four strips of aponeurosis from each animal which are tested for tensile strength.

Thyroidectomy and *nephrectomy* presented no serious problems.

After the animals had recovered from these operations, two incisions were made in the lumbodorsal aponeurosis, sutured, and allowed to heal. After varying intervals the animals were sacrificed and a strip of fascia 2 cm. wide excised on each side of the spinous process. The one strip contained the healing wounds, the other was intact. These strips were then tested for tensile strength as described in a previous paper (Douglas, 1952). Thus for each animal four values are available, i.e., the tensile strength of an upper wound and of a lower wound, and of an upper and lower intact strip of the same width of lumbodorsal aponeurosis from the other side (*Figs.* 530–532). The errors of the method were fully discussed in the previous paper. Further experience has impressed upon the writer that these are very considerable and that the 'cutting out' of sutures especially gives false values which cannot always be discerned and discarded.

FIG. 532.—Aponeurotic strip mounted in special clamps ready for testing in the tensiometer.

RESULTS

A scrutiny of *Table I*, which gives experimental details of the series, shows that in general the rate of gain of tensile strength of wounds in these animals is not altered by any of the experimental procedures we have carried out. There are individual variations from week to week due no doubt to the errors of the

Table I.—TENSILE STRENGTH OF HEALING INCISIONS IN THE LUMBODORSAL APONEUROSIS OF THE RABBIT IN CONTROL ANIMALS AND AFTER VARIOUS OPERATIONS

(Each centre value represents the mean of at least two observations)

DAYS	MEAN TENSILE STRENGTH IN GRAMMES				
	Control	Hypophysectomy	Adrenalectomy	Thyroidectomy	Nephrectomy
7	158	280	300	350	213
14	764	983	1007	452	688
21	423	752	1069	1152	972
28	904	883	1206	972	584
56	1132	1122	1312	—	1969
84	1718	1082	910	870	—
112	1103	1517	1205	1130	1556
140	916	1363	980	1762	1176
168	1695	2234	1966	1902	1472
196	2259	2202	2050	2128	—

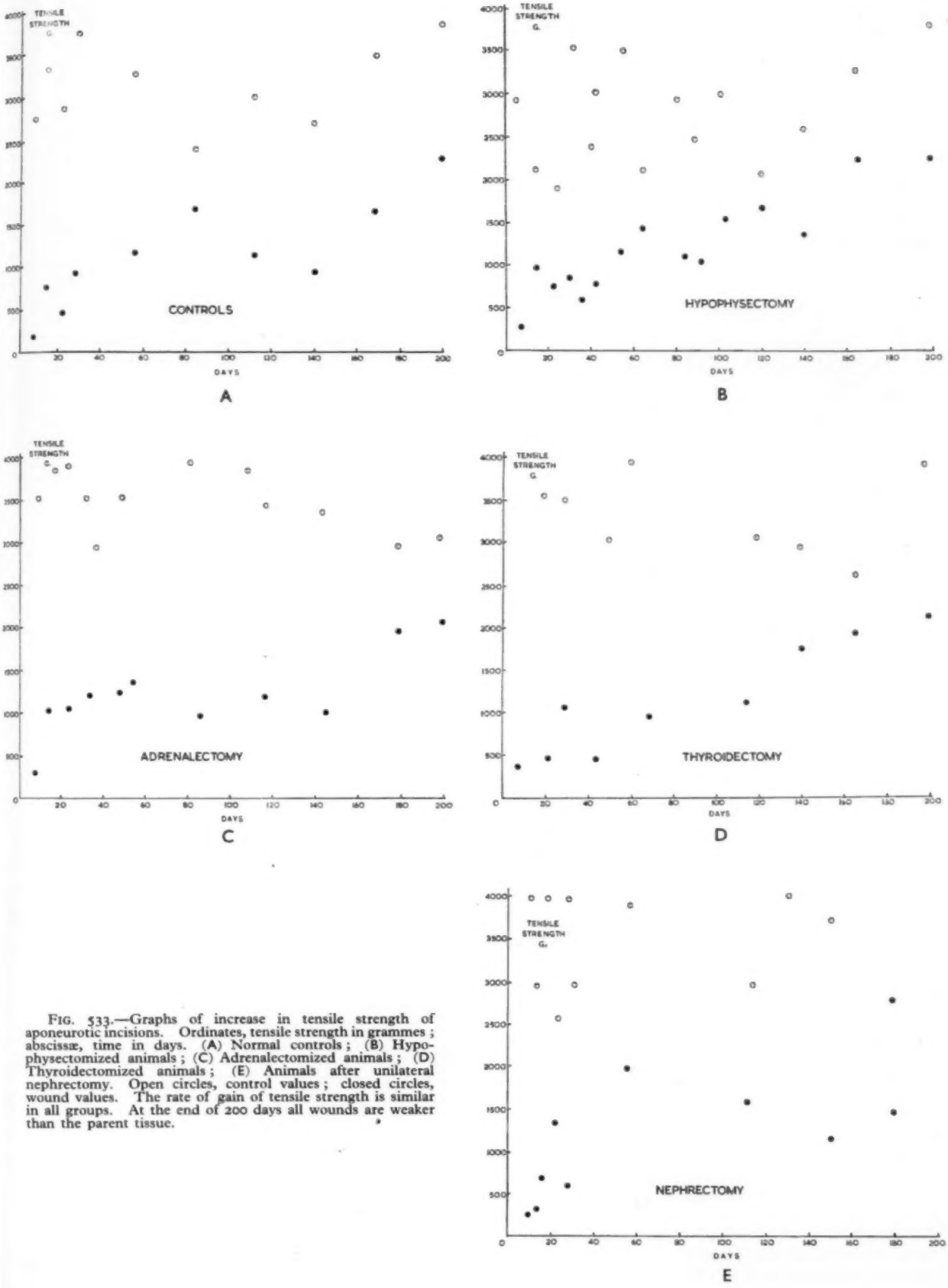


FIG. 533.—Graphs of increase in tensile strength of aponeurotic incisions. Ordinates, tensile strength in grammes; abscissæ, time in days. (A) Normal controls; (B) Hypophysectomized animals; (C) Adrenalectomized animals; (D) Thyroidectomized animals; (E) Animals after unilateral nephrectomy. Open circles, control values; closed circles, wound values. The rate of gain of tensile strength is similar in all groups. At the end of 200 days all wounds are weaker than the parent tissue.

method, but the general pattern is the same. There occurs a rapid gain in tensile strength to about 1000 g. in the first 28 days, and this is followed by a slow increase until the end of the period of observation. At the end of six months all wounds, including the controls, were appreciably weaker than the parent tissue.

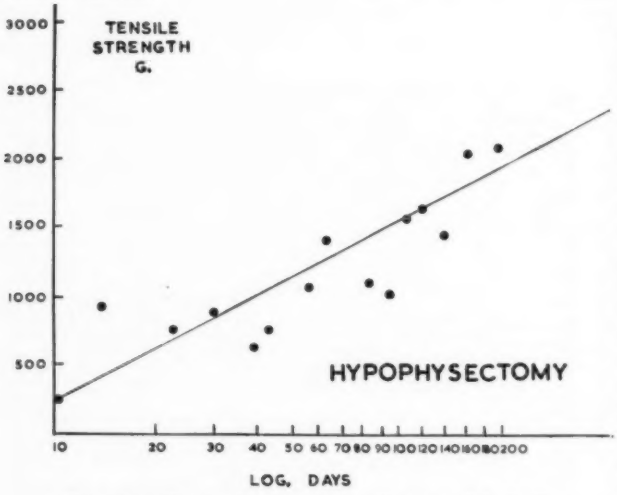


FIG. 534.—Graph of increase in tensile strength in healing aponeurotic incisions after hypophysectomy. Ordinates, tensile strength in grammes; abscissæ, time in days on logarithmic scale. The relationship tensile strength log time is linear.

The general curves of healing (*Fig.* 533) are similar to those previously recorded (Douglas, 1952) and are linear when time is recorded on a logarithmic scale (*Fig.* 534).

DISCUSSION

The role of hormones in wound healing has been discussed in detail by Davidson (1943, 1945). He points out that evidence of a 'wound hormone' is good for plants but poor for animals. English, Bonner, and Haagen Smith (1939) have isolated a substance from damaged tissue in plants to which the name 'traumatic acid' was given. In doses of a ten-thousandth of a milligram, this substance produces cell division and enlargement in other plant tissues. In addition, Sperti, Loofbourow, and Dwyer (1937) have produced cell-free filtrates from irradiated yeast cells with the property of stimulating vigorous growth in fresh yeast cells. This was confirmed by Davidson (1940).

Many attempts have been made to isolate wound hormones from animal tissues. Fischer (1930) showed that the infliction of wounds on growing fibroblasts in tissue culture speeded up growth and that the addition of saline extracts of wounded tissue cultures was able to stimulate growth in other cultures in which growth was slow because of lack of embryo juice.

Lorin-Epstein (1927) reported the presence of a substance in the serum of wounded animals which could accelerate the healing of wounds in other animals, but no confirmation of this work is forthcoming. Young, Fisher, and Young (1941) have demonstrated that a second wound, inflicted on an animal in which there is already a healing wound, heals more rapidly than the initial wound. They suggested that the latter may be liberating a wound-healing factor or factors. This was confirmed by Sandblom (1949) for incised wounds of the skin.

The only substances which have been clearly shown to modify the rate of wound healing when administered or withdrawn from the diet are cortisone (Howes, Plotz, Blunt, and Ragan, 1950), ACTH (Creditor, Bevans, Mundy, and Ragan, 1950), and ascorbic acid (Hunt, 1941; Hartzell and Stone, 1942). The first two substances, when administered in doses far larger than physiological amounts, inhibit fibroplasia. Lack of ascorbic acid leads to deficiency of intercellular substances, notably collagen, and thus to marked delay in the healing of incised wounds. The association of cortisone and ascorbic acid with wound healing is particularly baffling. Both substances are found in high concentration in the adrenal cortex, but they appear to have antagonistic effects on collagen metabolism. Cortisone is inhibitory, at least in large doses, while ascorbic acid stimulates the process. The problem is not elucidated by the finding here presented that the absence of both adrenals does not appear to modify wound healing—at least in aponeurosis.

The findings in relation to the pituitary and thyroid indicate that the endocrine glands which are concerned with growth do not seem to be concerned in the healing of this particular type of wound. It remains to be seen whether the same findings apply to granulating skin wounds.

SUMMARY

1. The rate of gain of tensile strength in incised wounds in the lumbodorsal aponeurosis of rabbits has been studied.

2. The animals were placed in five groups—a control group and four other groups in which hypophysectomy, bilateral adrenalectomy, thyroidectomy, and nephrectomy respectively had been performed.

3. The rate of gain of tensile strength was comparable in all five groups.

4. It is concluded that, under the conditions of these experiments, the pituitary, adrenal, and thyroid play no part in the healing of aponeurosis in the rabbit.

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SHORT NOTES OF RARE OR OBSCURE CASES

SQUAMOUS-CELL CARCINOMA OF THE STOMACH

By B. DREYER and J. H. LOUW
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SQUAMOUS-CELL carcinoma of the stomach is a very rare tumour. In 1943 Wood found 19 reported cases of gastric carcinoma containing squamous-cell elements. Only 9 of these were pure squamous epitheliomas—the others were adeno-acanthomas which contained both glandular and squamous elements. Since 1943 an additional 5 cases of adeno-acanthoma of the stomach have appeared in the world literature, but there have been no further reported cases of pure squamous-cell carcinomas (Bellegie and Dahlin, 1951). The rarity of this tumour is borne out by the fact that there has not been a single pure squamous epithelioma amongst almost 11,000 patients with carcinoma of the stomach operated on at the Mayo Clinic during the years 1907–55 (Dahlin, 1956).

Table I.—SUMMARY OF REPORTED CASES

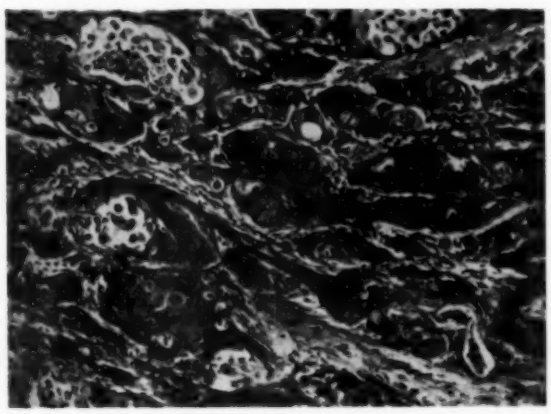
Case	*Authors*	*Sex*	*Age*	*Site*
1	Roerig (1895)	—	—	Lesser curvature
2	Eppinger (1895)	M.	—	Fundus
3	Borst (1902)	—	—	—
4	Calderara (1910)	F.	54	Pylorus
5	de Martel, Oberling, and Pernet (1930)	M.	41	Pylorus
6	Penna de Azevedo and Villela (1936)	M.	57	Lesser curvature
7	Weil (1936)	M.	47	Pylorus
8	Gauthier-Villars and Leger (1940)	M.	68	Pylorus
9	Scheffler and Falk (1940)	M.	49	Body
10	Present authors	F.	44	Pylorus

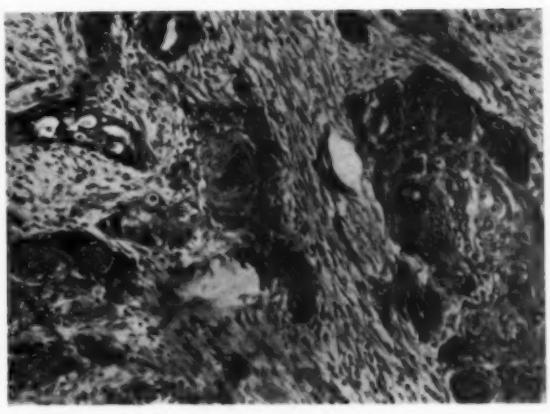
Table I, after Wood (1943), summarizes the reported cases of pure squamous-cell carcinoma of the stomach. This excludes all cases where the tumour was situated at the cardia as these are probably all primary œsophageal tumours.

The origin of a primary squamous-cell carcinoma in the stomach is obscure. Squamous-cell metaplasia of the gastric mucous membrane is almost unknown, although one such case has been reported by Hermann (1911). It has also been possible experimentally to induce squamous metaplasia of the stomach (Fütterer, 1904)—and to produce squamous-cell carcinoma of the pylorus in rats (Saxen, 1952).

A squamous epithelioma may, therefore, arise from an area of metaplasia of gastric mucous membrane. Alternatively, it may arise from heteropic

FIG. 535.—The opened stomach.





FIGS. 536.—Photomicrographs of sections taken from different parts of the tumour, and showing some histological features.

squamous epithelium, which is sometimes found along the lesser curvature but practically never at the pylorus. Thirdly, Wood (1943) believes that the squamous elements arise from direct stimulation of undifferentiated ' basal ' cells.

The rarity of squamous epithelioma of the stomach has stimulated the following report of a single case—the only one ever seen in the Departments of Surgery and of Pathology, University of Cape Town.

CASE REPORT

CLINICAL HISTORY.—On Feb. 15, 1956 a coloured female, aged 44 years, was admitted to Groote Schuur Hospital, Cape Town, with a history of a dull epigastric pain of two years' duration. The pain was related to meals, coming on immediately after eating and lasting 2–3 hours, and was partially relieved by antacids. For three weeks prior to admission the pain had been radiating to the back.

Her appetite was poor and she suffered from a distended feeling after meals. There was no vomiting although she often suffered from nausea. She had been constipated and had lost weight during the year prior to admission.

PHYSICAL EXAMINATION.—She was a fairly well-covered edentulous female. There was a small soft tender gland in the left supraclavicular fossa. Abdominal examination revealed a mass, about 5 cm. in diameter, in the right half of the epigastrium. It was firm, smooth, and well-defined, and moved with respiration. It was freely mobile in all directions. No other masses were felt. No free fluid or visible peristalsis were detectable. A succussion splash could not be obtained. Rectal examination was negative.

SPECIAL EXAMINATIONS.—Occult blood was present in the stools. Her hæmoglobin was 13 g. per cent and the blood-chemistry and liver function tests were normal.

A barium meal was not done as the clinical diagnosis of carcinoma of the stomach could be made with confidence.

AT OPERATION.—On Feb. 29 a Polya gastrectomy was done. The abdomen was explored through an upper midline incision. Occupying the pyloric end of the stomach there was a firm ulcerating tumour, 5 cm. in diameter, which on palpation was indistinguishable from the usual type of adenocarcinoma which occurs in this region. Enlarged but soft subpyloric and left gastric glands were present. There was no evidence of other glandular, hepatic, or peritoneal metastases.

A lower radical partial gastrectomy with an antecolic short-loop Polya-type of gastrojejunal anastomosis was performed. As far as could be ascertained, all carcinomatous tissue was removed.

PATHOLOGICAL REPORT (Dr. G. Selzer).—" Specimen is an opened stomach measuring 12 cm. along the lesser curvature and 19 cm. along the greater curvature. At the distal end is a carcinomatous ulcer with raised, rolled edges measuring 5 cm. in diameter. Histology is that of a squamous carcinoma which is well differentiated and shows foci of keratinization. The appearance does not indicate that it is superimposed on a chronic peptic ulcer. There were no lymph-nodes showing invasion by neoplasm."

The macroscopical appearance of the tumour is shown in *Fig.* 535.

The same histological features (*Fig.* 536) were shown in sections taken from different parts of the tumour.

PROGRESS.—The patient made an uncomplicated recovery, apart from a small degree of pulmonary atelectasis that occurred on the third post-operative day. She was discharged on March 10.

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ADENOCARCINOMA ASSOCIATED WITH SCHISTOSOMIASIS IN AN ECTOPIA VESICÆ

REPORT OF A CASE

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ECTOPIA vesicæ is one of the rare congenital deformities. If left untreated, an estimated 66–67 per cent of cases die before the twentieth year. Those that survive beyond that age usually succumb to repeated attacks of secondary infection. An uncommon complication is the development of malignancy, usually adenocarcinoma, in the extrophied bladder. The purpose of this paper is to report such a case, complicated by urinary schistosomiasis.

CASE REPORT

S. M. E. No. 57926. A 52-year-old male Egyptian farmer was admitted to hospital on April 17, 1955. He had been healthy and active until three months prior to

admission, when he noticed that blood mixed with urine was soiling his clothes. This had occurred before, but had always been of brief duration. This time it continued as a constant ooze until five days prior to admission when the hæmorrhage reached alarming proportions. Since that time no urine had been passed. There were no other symptoms besides lassitude and dyspnœa. The patient had never sought any medical advice prior to his admission.

On Examination.—The patient was a well-developed, muscular farmer. His skin was a pasty-yellow colour, the extremities were cold and clammy, and he was dyspnœic and restless. The pulse was rapid, thready, and easily compressible. Blood-pressure: systolic 30; diastolic unmeasurable. The mucous membranes were white and the eyelids slightly puffy. A pressure dressing was applied to the bleeding bladder surface and two pints of blood rapidly transfused. As the patient improved, a more detailed examination was carried out and this showed the entire bladder area to be replaced by a large, irregular, cauliflower mass, occupying both ureteral orifices, and bleeding freely. No urine excretion could be detected. An associated epispadias was present and the margin of the tumour stopped just short of the internal sphincter. Both testicles were present in the scrotum.

Laboratory examinations showed a blood-urea of 230 mg. per cent, a creatinine value of 7·9 mg. per cent, CO_2 27 vol., R.B.C. 950,000, Hb 4 g., and W.B.C. 12,500.

An attempt at catheterization of the ureteral orifices was successful on the right side. After dilatation a size 12 F. rubber indwelling catheter was passed into the right ureter. The left ureter was impassable (*Fig.* 537). Improvement was dramatic, and after a period of seven days the blood-urea had fallen to 116 mg. per cent and creatinine to 3·2 mg. per cent. Radiographs taken after intravenous injection of dye showed no excretion of the dye after two hours. The pubic bones showed wide separation (*Fig.* 538) and calcification (bilharzial) was demonstrated in the distal end of both ureters.

Fig. 537.—Cauliflower mass protruding from the extrophied bladder, which also shows the hæmorrhage and epispadias.

Fig. 538.—Radiograph showing wide separation of pubic bones and indwelling right ureteral catheter.

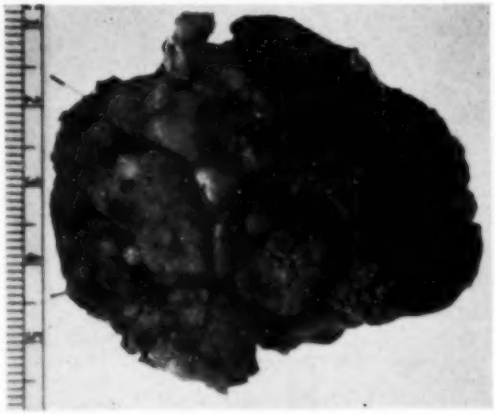

Fig. 539.—Gross photograph of extrophied bladder removed post mortem.

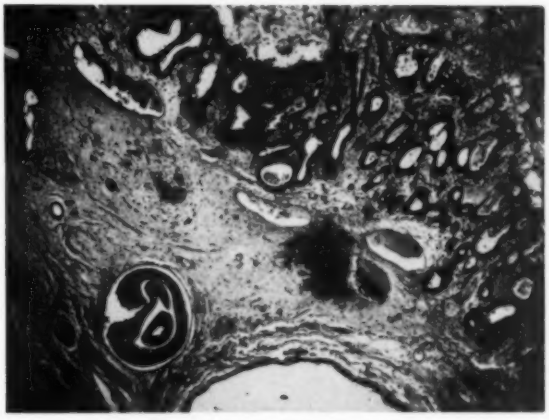

Fig. 540.—Glandular epithelium covering surface of bladder. Note schistosome worms in copulas inside vein in submucosa, and cystitis cystica. (× 75.)

Two weeks after admission it became impossible to replace the right catheter; continued blood-loss from the surface of the bladder made it difficult to restore blood-volume. In spite of repeated transfusions, the R.B.C. count was 3,850,000 and the Hb 9 g. A cutaneous ureterostomy was decided upon in an attempt to retrieve kidney function.

At Operation.—This was done through a modified gridiron incision on both sides. The right ureter was hugely dilated and tortuous. It was easily brought out to the skin and anchored there after ligature and section of the distal end. On the left side the ureter was completely stenosed owing to schistosomiasis. No urine was found above the stenosis. No attempt was made to bring it to the skin as the left kidney had evidently been functionless for a long time. Both internal iliac arteries

were ligatured below the obturator arteries in an attempt to reduce blood-loss from the extrophied bladder.

The patient progressed satisfactorily after the operation until the fifth post-operative day, when consolidation of the base of the right lung was noted with a concomitant rise in temperature and pulse. The patient's condition deteriorated rapidly and he died on the seventh post-operative day.

AT AUTOPSY.—A limited autopsy was performed and the bladder, prostate, seminal vesicles, and the obturator

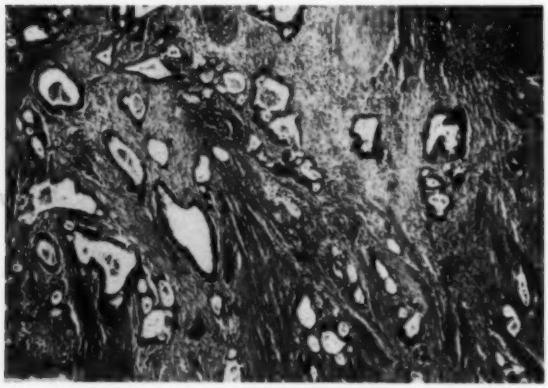

FIG. 541.—Photomicrograph showing invasion of muscle wall of bladder by adenocarcinoma. (× 75.)

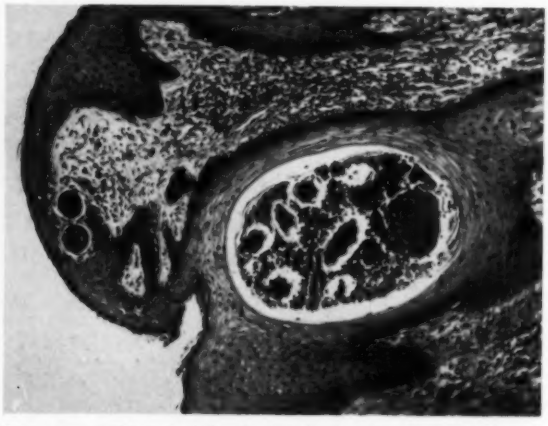

FIG. 543.—Skin of abdominal wall showing intra-epidermal abscess formation due to the ova of *S. hæmatobium*. (× 215.)

and internal iliac lymph-nodes were removed for histological study. In spite of the advanced disease, no extension was noted to adjacent viscera.

Gross Pathology.—An extrophic bladder measuring 6 × 5 × 3 cm. and showing a friable cauliflower tumour attached to the posterior wall of the bladder and fungating through anteriorly (*Fig.* 539). The abdominal skin around the bladder shows a thickened, dark epidermis. The prostate is slightly enlarged and has several small adenomata in the lateral lobes. The seminal vesicles cut with a gritty sensation, their tubules being dilated.

Microscopic Anatomy.—In the majority of the sections the transitional bladder has been replaced by glandular epithelium with the formation of many crypts, acini, and cysts (*Fig.* 540). Covering the glandular epithelium throughout is a thin layer of squamous epithelium which is missing in some areas owing to surface ulceration. The acini, crypts, and cysts are present in the submucosa and invade the musculature of the bladder (*Fig.* 541), and are lined by tall columnar cells, one or more layers thick. Goblet cells are seen in some. A few very large cysts lined by flattened epithelium are noted, with solid epithelial buds projecting into their lumina. Some are empty, while others contain granular eosinophilic secretions or are distended with mucus. The surface layers show secondary infection, hæmorrhage, and necrosis. Mitotic figures are noted in moderate numbers, the degree of anaplasia varying from one part of the tumour to the other. Between the glandular structures large

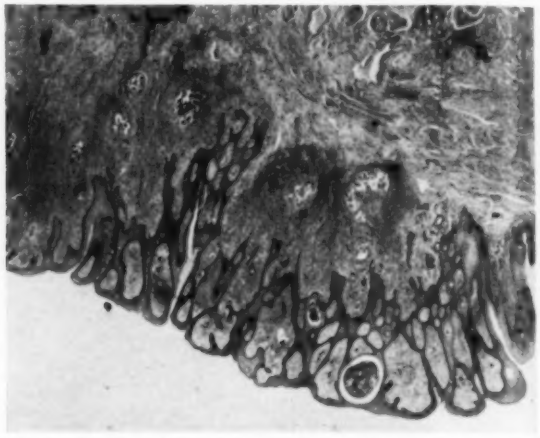

FIG. 542.—Skin of abdominal wall showing the marked pseudo-epitheliomatous hyperplasia, and aggregations of ova in epidermis and dermis.

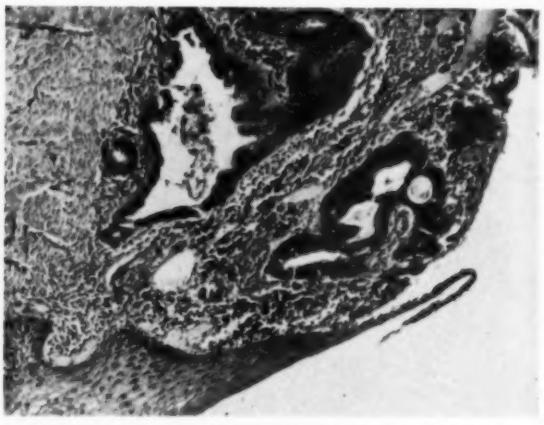

FIG. 544.—Junction of skin of abdominal wall with the adenocarcinoma. Note calcified ova to the left. (× 215.)

numbers of *S. hæmatobium* ova, both viable and non-viable, are noted, accompanied by a chronic inflammatory response. The cells in relation to the ova are foreign-body giant cells engulfing the remains of ova, plasmatocytes, lymphocytes, eosinophils, monocytes, and fibroblasts. A certain amount of fibrosis is also seen. Schistosome worms, some in copulas and others singly, are seen throughout (*Fig.* 540).

The skin of the abdominal wall shows acanthosis, hyperkeratosis, and pseudo-epitheliomatous hyperplasia, large irregular epithelial processes dipping down into the dermis (*Fig.* 542). *S. hæmatobium* ova (viable and calcified) and worms are found in the dermis surrounded by the usual inflammatory response, as well as in the epidermis forming acute intra-epidermal abscesses containing the ova (*Fig.* 543). One area is noted where the squamous epithelium of the epidermis ends and the adenocarcinoma of the extrophied bladder begins (*Fig.* 544).

The prostate shows an increase in the fibrous tissue content of the stroma. Hyperplastic changes are minimal.

Occasional ova are present in the stroma, accompanied by a minimal inactive inflammation. The prostatic urethra as viewed in the sections appears to be normal.

The seminal vesicles show dilated tubules filled with granular and hyaline secretions. Large numbers of calcified ova are packed in the stroma with plaque formation and advanced fibrosis. An occasional ovum is seen in the walls of the tubules in the process of extrusion into the lumen. The lymph-nodes examined show no metastases.

DISCUSSION

This case presents several unusual features. Owing to his profession as a farmer, the patient contracted bilharziasis in his early childhood, and undoubtedly had repeated re-infections. Despite his strenuous mode of life and the fact that he never wore a protective appliance and was constantly exposed to the irritation of soiled and dirty clothing, he lived and was apparently healthy to the unusual age of 52 years. It is interesting that the symptom that caused him to seek medical advice was the severe and exsanguinating hæmorrhage and not the symptoms resulting from the blockage of his ureteral orifices, first by the bilharzial strictures and later by the carcinoma.

Although we have seen several cases of bilharzial infection in extrophied bladders, none of the patients lived long enough for carcinoma to develop. The histological features of the case have been modified by the presence of the ova and worms and the accompanying chronic inflammation, which in themselves are often factors in the causation of cystitis glandularis, cystitis cystica, and squamous metaplasia in the bilharzial bladder. The presence of the ova and worms in the skin of the abdominal wall, together with the formation of intra-epidermal abscesses, is another finding of interest.

SUMMARY

1. The clinical features, laboratory investigations, and management of a 52-year-old bilharzial patient with ectopia vesicæ and adenocarcinoma are reported.

2. The pathology of the extrophied bladder, skin of the abdominal wall, prostate, and seminal vesicles is reported.

3. The unusual features of the case are discussed.

Acknowledgement.—We wish to thank H.M.I. R. W. Trimmer, U.S.N., and Mr. Azmy Yassa, of the Pathology Department for valuable technical assistance, as well as Mr. Dick Kurkdjian and Mr. Antranig Hagopian for their excellent photographic work.

FOREIGN BODY RETAINED IN THE URETHRA

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FOREIGN bodies are not uncommonly introduced into the urethra, in both males and females. In the female the object is usually voided or passes into the bladder: in the male the passage to the bladder is longer and the body may be retained in the urethra. The following case is remarkable for the length of time during which a foreign body remained in a male patient's urethra without occasioning symptoms.

CASE REPORT

A 24-year-old man was admitted to the East Glamorgan County Hospital, Church Village, complaining that for the previous three months he had pain "in the crutch" when he had his bowels open: he had occasional burning pain on passing water. He stated that nine years previously in the course of a 'night out', two friends had pushed an open safety pin along his urethra: this had never come out. Abdominal and rectal examination revealed no abnormality, but there was a palpable foreign body some 9 cm. long in the bulbar urethra. There was no manifest urethritis. A radiograph (*Fig.* 545) showed an opened-out safety-pin encrusted in phosphates lying in the perineum, its pointed anterior end uncovered. Urethroscopy revealed no urethritis and the point of the pin could be readily visualized: it was introduced into the urethroscope by manipulation in the perineum, grasped with an alligator forceps and withdrawn with the urethroscope within which the pin point was safely held by the forceps. (*Fig.* 546.) After operation very slight thickening of the bulbar urethra could be felt.

COMMENTARY

Introduction of foreign bodies into the urethra is probably more common in females than in males, as their use in the former is associated with attempts

FIG. 545.—Pre-operative radiograph showing the opened-out pin lying in the perineum.

both at abortion and masturbation. Children sometimes introduce various articles when in an inquisitive frame of mind, but pliable bodies such as straws, feathers, bootlaces, string, and chewing-gum are commoner than those of a rigid nature, such as pins, pencils, and crochet hooks. The classical method of removing an ordinary pin or a safety-pin

FIG. 546.—The pin after withdrawal showing heavy encrustation.

in which the centre loop has been uncoiled and straightened out is to push the point, which lies anteriorly, the pin having been introduced blunt end first, through the floor of the urethra, underlying corpus spongiosum and skin: the pin can now be turned and the blunt end pushed forward towards the external meatus, to be grasped by an alligator forceps and withdrawn (Winsbury-White and Loughnane, 1948; Romanis and Mitchiner, 1948). Such a manœuvre would not have been possible in the case cited because of the bulk of concretion laid down around the shaft of the pin. Furthermore, the method of removal employing the urethroscope is less traumatizing.

If the body is left in the urinary stream it generally becomes the centre of deposition of phosphates and urates, which cover it and form a bulky concretion. In the urethra complications of retained foreign bodies are rare, although retention of urine, dysuria, infection, and urethritis, extravasation of urine, and periurethral abscess may occur.

The above case illustrates three features of intra-urethral foreign body: first, that it may remain in the urethra for many years without causing symptoms; second, that it acts as the centre of concretion formation; and, third, that it may remain in situ for a very considerable period without any of the complications which might reasonably be expected.

My thanks are due to Mr. R. A. Mogg, Urologist, United Cardiff Hospitals, for permission to publish this case.

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REVIEWS AND NOTICES OF BOOKS

The Treatment of Fractures. By LORENZ BÖHLER, M.D., Director of the Accident Hospital, Vienna; Professor of Accident Surgery, University of Vienna. Volume I. Translated from the Thirteen German Editions by HANS TRETTER, HELEN B. LUCHINI, FRANK KRUEZ, OTTO A. RUSSE, and ROBERT G. B. BJOLNSON. 9⅜ × 6⅝ in. Pp. 1104 + xx, with 1721 illustrations. 1956. New York: Grune & Stratton. $24.50.

BÖHLER'S book on fractures has interested surgeons in this country since 1935 when Hey Groves translated the fourth German edition. Much has happened during the last two decades and there has been an unparalleled amount of trauma in the world.

Probably Dr. Böhler has treated more fractures than any other surgeon, for he served not only in both world wars but also in Spain in 1937. With this background of continued experience in fractures over the years, it is little wonder that his book, which has reached its thirteenth edition in German, should be a classic.

This new English edition will be as popular as former editions, and anyone who has fracture cases under his care will of necessity be forced to have this book for reference.

The illustrations are uniformly good, especially the clinical photographs. Böhler has been wise to include a number of photographs showing the bad results of incorrect treatment; such photographs make a real impression on the reader.

The chapters dealing with fractures of the small bones of the body are very practical and often contain a wealth of practical ideas as to treatment. If Volumes II and III are up to the same standard as the present one there can be little room for criticism of this great work.

Operative Surgery. Edited by CHARLES ROB, M.C., M.Chir., F.R.C.S., Professor of Surgery, St. Mary's Hospital, London; and RODNEY SMITH, M.S., F.R.C.S., Surgeon, St. George's Hospital, London. 11¼ × 8¾ in. Vol. 1, pp. 1–342 + xviii, with numerous illustrations. Vol. 2, pp. 343–547 + xii, with numerous illustrations. 1956. London: Butterworth & Co. (Publishers) Ltd. £5 10s. per volume.

SINCE the second world war there has been a spate of books on operative surgery published in this country and in America, and yet another comprehensive work on this subject has now appeared—and we think it justifies itself.

The first two volumes of this large exhaustive work are excellent and have whetted our appetites for the other volumes.

The essential feature in this new *Operative Surgery* is the incorporation of the maximum number of illustrations and the minimum of text. This is an ideal combination, as all the very numerous illustrations are well drawn and beautifully reproduced. This is rather surprising, as a large number of different artists have been employed to illustrate the various chapters.

The general editors, Professor Charles Rob and Mr. Rodney Smith, deserve much credit for the way in which they have inspired the various contributors to work to a definite plan, so that each operative procedure is illustrated in definite stages.

The first volume is divided into three parts: Part I is introductory and deals with a large amount of important yet often neglected technique—the use of ligatures and suture materials, diathermy needle biopsy, use of retractors, radium needle insertion, and wound dehiscence.

These subjects are barely dealt with in the general run of books on operative surgery. This section should prove of real value to men who are working for higher surgical examinations such as the Mastership in Surgery or the Fellowship of the Royal Colleges.

Part II is devoted to the surgery of trauma; the excision of wounds, primary suture of severed vessels, nerves, and tendons. An excellent chapter on the local care of burns is to be found in this section.

Wounds of the various parts of the body are dealt with in a very excellent and practical manner; the section on injuries of the chest, written by Nicholson, deserves special mention.

Part III is concerned with the surgery of the abdomen and is outstanding, especially Milnes Walker's chapters on the surgery of hypertension.

Volume 2 is a continuation of Part III of Volume 1 and is devoted entirely to the surgery of the abdomen. The surgery of hernia is exceptionally well illustrated and the drawings are excellent. Rodney Smith deals with pancreatic lesions in a lucid and practical manner. Lockhart Mummery is following in his father's footsteps and deals with the subject of sigmoidoscopy in an interesting and lucid style.

This is an outstanding work on operative surgery; it is novel, practical, and portrays all that is best in British operative technique. It is a production of which British surgery may well be proud.

Wire Brush Surgery. By JAMES W. BURKS, jun., M.S., M.D., Associate Professor of Clinical Medicine (Dermatology), Tulane University of Louisiana School of Medicine, New Orleans. 9¼ × 6 in. Pp. 154 + xxiv, with 68 illustrations. 1956. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell.) 51s.

WIRE brush surgery is a popular line amongst the dermatologists in the United States of America but is not practised extensively in this country.

This monograph contains a summary of the known published experiences of the pioneers of abrasive surgery and the author's personal experiences in over seven hundred and fifty planings.

The apparatus consists of an electric motor, very similar to that used in dental surgery, a flexible cord, and a handpiece. To the handpiece is connected a wire brush. The anæsthetic is ethyl chloride, which is blown on to the surface that is to be brushed.

Many and varied skin conditions can be treated with wire brush surgery and the results given in this monograph appear to be excellent.

There seems to be a definite demand for this type of treatment for certain skin conditions.

Anatomical Techniques. By D. H. TOMPSETT, B.Sc., Ph.D., Prosector to the Royal College of Surgeons of England. With a Foreword by SIR CECIL WAKELEY, Bart., K.B.E., C.B., LL.D., F.R.C.S. 10 × 6½ in. Pp. 240 + xvi, with 83 illustrations, 9 of which are in colour. 1956. Edinburgh: E. & S. Livingstone Ltd. 35s.

IN both an erudite and informative historical introduction, Miss Dobson tells us that there have been very few books devoted to this subject alone. The present one is a comprehensive guide to the preparation of specimens of vertebrate anatomy and in its four parts, which deal respectively with the preparation and mounting of anatomical specimens, the illustration of dissections, casting in synthetic resin, and the preparation and mounting of differentially stained sections of the brain, the reader is given a very full account of how best to prepare and exhibit dissections. The book is beautifully produced, the large clear type and adequate spacing making the text easily readable, while the illustrations, several of which are in colour, are excellent. As Sir Cecil Wakeley says in his foreword, it is instructive and very practical and should interest not only students but also surgeons who participate in the teaching of anatomy and surgery and should prove invaluable to all who are interested in the anatomy of the human body.

The Recurrent Laryngeal Nerves in Thyroid Surgery. By WILLIAM H. RUSTAD, M.D., Assistant Clinical Professor of Surgery. Pp. 47 + xiii. 1956. Oxford: Blackwell. 34s.

THIS small but profusely illustrated monograph contains some useful anatomical details concerning the recurrent laryngeal nerves, especially the various variations in their distribution.

Injury to the recurrent laryngeal nerves is not common in this country, probably because surgeons are careful in their dissections during thyroidectomy.

This monograph depicts the relationship of the recurrent nerve and the inferior thyroid artery in some 250 drawings; but what a pity the artery is depicted as a single vessel entering the gland, whereas it generally breaks up into six or eight branches, and it is the relation of the nerve to these numerous branches that is so important.

Surely it would have been better to illustrate this book with real anatomical drawings and not schematic ones.

Munro Kerr's Operative Obstetrics. By J. CHASSAR MOIR, M.A., M.D., F.R.C.S. (Ed.), F.R.C.O.G., Nuffield Professor of Obstetrics and Gynæcology, University of Oxford. Sixth edition. 9¾ × 6½ in. Pp. 1008 + x, with 402 illustrations and 4 colour plates. London: Baillière, Tindall & Cox. 105s.

WE welcome the new edition of this well-known work which has been known to the medical profession of this country since 1908. Professor Chassar Moir has followed in the footsteps of Munro Kerr and has produced the sixth edition in a manner which will please not only the obstetric specialists in this country but also those from overseas.

A work of this calibre is of the utmost importance to-day when many general practitioners who are especially interested in obstetrics require a book such as this for reference purposes.

Those junior obstetric officers in our hospitals who are working for higher diplomas will find this book of real value.

One of the features of the book is the excellence of its many illustrations. We would like to congratulate Professor Moir on an excellent production.

Pre- and Post-operative Care in the Pediatric Surgical Clinic. Edited by WILLIAM B. KIESEWETTER, M.D., Associate Professor of Surgery, University of Pittsburgh School of Medicine. Pp. 347. 1956. Chicago: The Year Book Publishers. $7.00.

THIS is a useful synopsis of the pre- and post-operative care of surgical cases in children. It cannot possibly replace any of the well-known works on pediatric surgery.

Its usefulness to house surgeons and ward sisters is considerable and senior students will find an excellent framework on which to build subsequent knowledge.

Resident medical officers in charge of children's wards will find this a useful book which will easily fit into their coat pocket.

BOOK NOTICES

[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest to our readers.]

Training of the Lower Limb Amputee. By DONALD KERR, B.B.A., Director, National Institute for Amputee Rehabilitation, Lodi, New Jersey; and SIGNE BRUNNSTROM, M.A., Consultant in Amputee Training, Institute of Physical Medicine and Rehabilitation, New York University—Bellevue Medical Centre. With an Introduction by T. CAMPBELL THOMPSON, M.D. 9¼ × 6 in. Pp. 272 + xxiv, with 153 illustrations. 1956. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell.) 50s.

Lesions of the Cervical Intervertebral Disc. By R. GLEN SPURLING, M.D., Professor of Neurosurgery, University of Louisville School of Medicine, Louisville, Kentucky. 9½ × 6 in. Pp. 134 + xvi, with 41 illustrations. 1956. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell.) 36s.

Diagnostic Différentiel Radiologique des Ulcérations Gastriques. By GEORGES CANDARDJIS. With a Foreword by Dr. P. PORCHER and Prof. L. BABAIANTZ. 10 × 6½ in. Pp. 188, with 92 illustrations. 1956. Paris: Masson. 1,500 fr.

The Biliary Tract. By JULIAN A. STERLING, A.B., M.D., M.Med.Sc., Sc.D., F.A.C.S., Staff Surgeon, Albert Einstein Medical Center and the Graduate Hospital; Chief Surgeon, Psychiatric Hospital. 9 × 6 in. Pp. 424 + x, with 94 illustrations and 2 coloured plates. 1956. London: Baillière, Tindall & Cox. 80s.

Traité de Technique Chirurgicale. Vol. VIII, Appareil urinaire et appareil génital de l'Homme. By BERNARD FEY, RAYMOND DOSSOT, and LOUIS QUÉNU. Second edition. 9¼ × 6¼ in. Pp. 870 + viii, with 899 illustrations. 1956. Paris: Masson et Cie. 5,800 fr., paper cover; 6,600 fr., board cover.

Hommage à René Leriche. By SES ÉLÈVES. 9½ × 6¼ in. Pp. 494, with 197 illustrations. 1956. Paris: Masson et Cie. 3,000 fr.

Chirurgie de L'Estomac. By R. GUEULLETTE. 9½ × 6¼ in. Pp. 584 + viii, with 117 illustrations. 1956. Paris: Masson et Cie. 4,000 fr., paper cover; 4,600 fr., board cover.